

Fostering Critical Teacher Agency: The Impact of a Science Capital Pedagogical Approach

Heather King¹ and Effrosyni Nomikou²

¹School of Education, Communication & Society, King's College London

Waterloo Bridge Wing, Franklin Wilkins Building, London SE1 9NH, United Kingdom

Heather.1.king@kcl.ac.uk

² Department of Education, Practice & Society, UCL Institute of Education

20 Bedford Way, 20 Bedford Way, London WC1H 0AL, United Kingdom

e.nomikou@ucl.ac.uk

Corresponding Author: Heather King

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Abstract

Teacher agency is considered key in shaping teachers' professional identities and decision-making capabilities, and teaching practice. We suggest that the concept of agency also constitutes a useful tool for evaluating the successful implementation of new teaching approaches. In this paper we discuss findings from a teacher professional development programme aimed at enabling science capital building approaches in the classroom. By applying the lens of agency we identified developments in teachers' sense of purpose, mastery, reflexivity and autonomy. We also identified factors which appeared to either promote or constrain the acquisition of agency.

The science capital building pedagogy and the associated professional development programme are underpinned by a social justice agenda. In supporting teachers to 'tweak' their practice in ways that provide more opportunities for more students to see the relevance of science to their lives, and to identify with science, we suggest that the agency fostered by the intervention may best be defined as critical teacher agency.

Keywords: agency; science capital; social justice; professional development

Introduction

The role of teacher agency, and its importance for effecting change in education, has been largely under-researched, both in terms of theory development and practice research (Biesta, Priestley, and Robinson, 2015). It is only in the last few years that a number of studies have started to examine the significance of teacher agency by, for example, seeking to characterise and understand the elements of agentic teachers' practices in the light of contemporary schooling (Pantić 2015; van der Heijden, Geldens, Beijaand, and Popeijus 2015; Robinson, 2012; see also Eteläpelto, Vähäsantanen, Hökkä, and Paloniemi, 2013; Vähäsantanen, 2013). Researchers are also exploring ways to support new teachers to develop greater agency in order to act more strategically in the face of increasing accountability measures (Dover,

Henning, and Awarwal-Rangnath, 2016). Our aim in this paper is to add to this growing body of scholarship. Specifically, we explore the potential of using agency as a lens for evaluating the adoption and effect of a new educational practice. Our study draws on data from a ‘science capital’ professional development intervention, described below, aimed at increasing equity in science by supporting more students, from more socially and ethnically diverse backgrounds, feel able to engage in science learning. In this way, our work responds to the increasing number of calls worldwide to develop teachers as agents of change for social justice (Florian, 2009; Pantić and Florian, 2015; Zeichner, 2009) and, moreover, offers a practical approach for teachers faced with the daily demands of contemporary schooling (Buchanan, 2015). The equity focus of the professional development, meanwhile, aims to address the low numbers of ethnic minority and economically disadvantaged students continuing to study or work in science (see Elias, Jones, and McWhinnie, 2006; Archer, DeWitt, Osborne and Wong, 2012; Wong, 2016). We begin by briefly discussing the concept of agency both broadly and in the context of education.

Theorising Agency

The concept of agency has been conceptualized in a range of ways. Some conceptualisations of agency emphasise the ability of individuals to create change in the world. Giddens (1984), for example, argues that agency entails the ability to change one’s life in a way that ‘makes a difference’. Biesta and Tedder’s (2007) explanation of the concept affords individual ‘actors’ intrinsic control of their actions: their definition of agency also accounts for the actor’s own perspective and learning as manifested in the way in which actors ‘critically shape their responses to problematic situations’ (2007: 138). Other articulations of agency (Davies, 2010) highlight the capacity to stand back from events and ideas and critically examine what might be achieved. In standing back, agency can take the form of resistance (Sannino, 2010).

Importantly, articulations of agency as resistance and articulations that emphasise the creation of change share a foundational principle in that they similarly specify that all decisions – to act, or to resist – are intentional, rather than habitual or subconscious (Giddens, 1984)

From a psychological perspective, Bandura (2001) defines agency in terms of core characteristics within the individual. These include intentionality and forethought, self-regulation, and self-reflectiveness. Further, Bandura argues that the key mechanism of agency is efficacy: a person's belief in their capabilities to exercise some control over events. Other theorists, however, have argued that agency is more complicated than merely an individual's capacity and will, to act or resist. For instance, Margaret Archer (2000) contends that by placing the power of agency solely in the domain of the individual, human existence is reduced to merely individual action. However, Archer also warns against the converse. By theorizing agency solely at the structural level of society, individuals are effectively diminished to nothing more than 'society's beings' with no personal agency for themselves. The diametric positions described by Archer form the basis of the structure-agency dialectic. This dialectic continues to shape sociological thinking, with many proponents arguing that agency cannot be divorced from wider structural factors such as the social and material environment of which they are a part (Biesta and Tedder, 2007; Barton and Tan, 2010). It is perhaps most productive, therefore, to conceptualise individual agency and social structures as being mutually constitutive and highly interdependent (Eteläpelto et al. 2013; Lasky, 2005; Vähäsantanen 2013; van Oers 2014).

In recognizing the interplay of individual efforts, available resources and contextual factors, Biesta and Tedder conceptualise agency as an ecology (2007). This framing recognizes the influence of past events and future orientations in the decision-making of here and now. In this way, Biesta and Tedder's framework builds on the theorisations of

Emirbayer and Mishe (1998) who argue that the complexity of agency can only be fully understood if considered within respect to the flow of time. In recognizing agency as a process informed by past events and experiences, but oriented toward future possibilities, agency may be depicted as something that is achieved within the contingencies of the moment and in context, rather than something which is possessed and immutable. In this paper, we too understand agency as a fluid expression shaped by the individual and the wider temporal structures in which that individual exists. We thus attempt to situate our data comprising individual teacher interviews within the wider context of particular school systems.

Theorising Teacher Agency

Looking specifically at the enactment of agency within education, there is a growing body of work (e.g. Lasky 2005; Saninno 2010) that has examined the extent to which teachers are able to deploy agency in their professional practice. Eteläpelto et al. (2013) use the concept of agency to interpret teachers' reflections on their identity and purpose as teachers. They argue that agency is necessary for teachers' renegotiation of professional identities in the light of policy reforms and changing educational practices. Vähäsantanen (2013) and Saninno (2010) both highlight the role of agency in teachers' decision-making and the extent to which they choose to comply with, or resist, educational reform measures. Buchanan (2015) similarly recognizes the role of agency in shaping the ways teachers respond to reform contexts, describing the process by which teachers actively apply their prior experiences and identities to conduct their educational remits in terms of 'carving out' one's professional agency.

Pantić (2015) argues that there is a lack of clarity about the nature of teacher agency and the ways in which it operates in schools. She suggests that there is a need to identify the appropriate variables that contribute to teacher agency alongside the potential factors that

may support or hinder its enactment. To this end, Pantić (2015) has developed a model for the study of teacher agency building on the extant theorisations of human agency (Giddens 1984; Archer 2000), together with recommendations and refinements for practical application proposed by a committee of teachers, head teachers, local and national policy makers, and teacher educators. The components of this model emphasise the interactions between individual action and wider structures, and comprise purpose, competence, autonomy and reflexivity. The nature and use of these components as units of analysis are discussed further below in the Methodology section. van der Heijden et al. (2015) have likewise identified components of agency in their analysis of primary school teachers who acts as agents of change. They argue that teachers' agency is engendered by an internal drive to reflect, and by the need to meet external demands. In recognising what they term the 'inside' and the 'outside' in this way, these authors would appear to conceptualise agency in ecological terms similar to Emirbayer and Mische who propose that 'actors are conceived of not as atomized individuals, but rather than active respondents within nested and overlapping systems' (1998: 969).

In this paper we draw on data from the Enterprising Science study, a five year research and development project aimed at engaging diverse students with science. The project included a year-long teacher professional development programme in which teachers were supported to develop and apply a 'science capital' pedagogical approach to their practice (Nomikou, Archer and King 2017). We report on our conceptualisation of science capital in full elsewhere (Archer, Dawson, DeWitt, Seakins, and Wong 2015; King, Nomikou, Archer and Regan 2015), but in essence, we define science capital as the science related resources and contacts that an individual possesses, and which are duly recognized by others in ways that enables the individual to 'get on' in life. The science capital pedagogical approach, developed in partnership with teachers, involved amending or 'tweaking' the

teachers' practices to promote the eliciting and valuing of students' existing capital – acquired in their home and cultural contexts – and, thereafter, the linking of such capital to more widely recognised forms. The wider project was not originally designed as an exploration of teacher agency; rather our aim was to open up the field of science learning to those who have traditionally felt that 'science was not for them' (King et al. 2015; Nomikou et al. 2017). However, in reviewing our partner teachers' implementation of the science capital pedagogical approach over the course of the year, we noted that the teachers were proactively shaping their professional practices and classroom contexts in ways that were over and above the amendments to their pedagogy that we had initially proposed. Given the significance afforded to agency in the above mentioned literature, we felt that agency could provide a useful conceptual lens through which to interpret our data and critically assess the broader impact of our professional development on the participating teachers and students. Hence in this paper we ask:

- (1) In what ways did partner teachers exhibit agency as a result of implementing the science capital pedagogical approach?
- (2) What factors appear to either facilitate or constrain teacher agency in the context of a science capital building pedagogy?

Research Design and Methodology

In the academic year 2015 – 2016, our project team worked in partnership with nine science teachers employed in six London schools. The teachers were a diverse group in terms of experience (n=3 up to four years; n=4 between five and ten years; n=2 over 20 years), and demographic profile (gender: n=3 male; n=6 female; ethnicity: n=3 Black; n=3 Asian; n=3

White). They came from a broad range of London schools – from inner-city comprehensives serving ethnically diverse populations to a private middle school situated in a more economically privileged area. The teachers either applied to the project or had been recruited through prior contacts at their schools. All received a stipend for attending two weekend training days and agreed to participate in regular lesson observations and feedback discussions. With the aim of building trust and ensuring a strong rapport, each teacher primarily worked with one researcher. The close working relationships, and regularity of lesson observations and feedback discussions (at least once every two to three weeks throughout the year) enabled small amendments to be implemented iteratively leading to a cumulative change in approach by the end of the year.

The concept of science capital, and the notion that some individuals may have more than others, helps us understand why some pupils participate in post-compulsory (post-16) science and others do not, and why some groups remain underrepresented in science and why some students do not see science as being ‘for them’. The concept also highlights the role of the wider field in recognising or acknowledging an individual’s capital and thus challenges educators to reflect on ‘what counts’ as knowledge in science. In supporting teachers to validate the breadth of learners’ lives and experiences, we hoped to help more young people from diverse backgrounds feel able to participate in science. In this way, our aims were very much underpinned by a social justice agenda.

To document the progress and effects of the professional development programme we conducted interviews with our partner teachers at the beginning and end of the year, ran focus groups with students, and made detailed observations of the lessons in which the teachers sought to adopt a science capital building approach. Following such lessons, we spent time with the teachers reflecting on what had worked well, or not so well, and made field notes of such conversations. These reflections were then used to inform subsequent efforts and

modifications to lessons. All data collection was conducted under the University's ethical approval of the wider research programme of which this study forms a part. Teacher and student participants (in focus groups) gave written consent for the data to be collected during their participation in the programme.

To identify instances of agency, we borrowed from the work of Pantić (2015) and van der Heijden et al. (2015). Pantić argues that the defining features of agency are intentionality or sense of purpose, competency to achieve such purpose, and a degree of autonomy to act. Additionally, Pantić notes that all three features afford the individual with the ability to reflect upon their actions and envisage opportunities for change. Pantić accepts that autonomy is relative, and that teachers are automatically subordinate to their heads of department and school. We would also note that a teacher's agency can also be shaped by the expectations of the students they teach (discussed in further detail later), and of course by the requirements of the curricula they are obliged to teach. Nonetheless, like Pantić we argue that there is scope for teachers to make autonomous choices about the ways they teach and manage their classes.

In their discussions of agency, van der Heijden et al. (2015) identify the personal characteristics of teachers who, they feel, exhibit or are able to attain it. They suggest that teachers who act agentially regularly and systematically reflect on their practice throughout the course of their careers. Secondly, they note the significance of a strong foundation in both their subject matter and pedagogical practice. Without such mastery, combined with reflexivity, teachers would be less able to recognize problems in their work and broader context, and acknowledge the need for a solution. Thirdly, van der Heijden et al. suggest that teachers must make 'creative initiatives' and dare to take risks and challenge the status quo. To take risks, and admit that problems exist requires the fourth characteristic: being collegial and operating in a collaborative work space. van der Heijden et al. thus note that agentic

teachers recognize the importance of collaboration not only for providing peer support, but, more significantly, for enabling change across the whole school.

In combining the frameworks of Pantić (2015) and van der Heijden et al. (2015), we examined our data for instances of purpose, mastery, reflexivity and autonomy. To identify purpose we looked for instances of teacher commitment or motivation towards the social justice agenda for which the science capital approach was designed. For mastery, we looked for instances of competence and confidence in the ways teachers employed the science capital pedagogy. For autonomy we sought instances of decision making and also risk taking. We also looked for instances when teachers sought collective efficacy by working with colleagues. Finally, for reflexivity, we identified instances when our partner teachers engaged in monitoring their practices and changing them accordingly. These moments are comparable to ‘critical reflection’, the conscious consideration of the ethical implications of teaching practice on students combined with deep examination of personal beliefs and assumptions about human potential and learning (Larrivee 2000, 2008).

To identify instances of the four themes, we coded our data manually, examining and re-examining in an iterative manner our teacher interviews, field notes, and observations of classroom lessons. We also reviewed the student focus group data to see whether the students had perceived any changes in their teacher’s purpose, or had any opinions relating to increased confidence or mastery with respect to their teachers’ practice. In the findings presented below, all names and identifying details have been anonymised.

Findings

Our analyses of teacher agency were guided by our two research questions. We answer each in turn.

Developments in agency

Our first research question asked in what ways did the teachers exhibit agency as a result of implementing the science capital pedagogical approach. As discussed above, we argue that agency comprises four theoretically derived components of purpose, mastery, reflexivity and autonomy. We present instances of each component below, however we would also note that due to the contingent nature of agency and its iterative transformation over time, the categories and illustrative examples are not discrete but instead overlap.

Purpose

The aim of the professional development programme was to support teachers in implementing science capital building approaches – a rationale underscored by a social justice agenda. To this end, we hoped our efforts would result in teachers developing a new momentum in their work and review their purpose as teachers. We hoped that they would see their role as one of supporting more students to see the value of science and adopt practices that reached beyond the ‘banking’ model of education (Freire, 2000 [1970]). In line with this aspiration, we observed significant shifts in the value of the teachers towards more student-centred practices. Both Mr Hobbes and Mr Okello, for example, reported their efforts in making lessons more personally relevant to their students. Both also noted that this change resulted in their lessons being more engaging, and by extension, better:

And it’s making life a lot easier because you’re not ...you’re not just like bombarding them with information, you’re drawing things that they understand that is relevant to them, that makes their lessons a bit more interesting and a little bit more, you know, successful I think. (Mr. Hobbes, post-intervention interview)

What science capital has made me realise is you can personalise that context. So it doesn’t have to be ... even if you do give a context it doesn’t have to be a ... let’s give an example ... a scientist trying to make a bridge, it could be your family story or it could be your personal experience in the past. So I’ve found with science capital I’m taking the context and I’m applying it to the experience of the individual students. I think that makes it far more relevant and it’s easier for them to engage with. (Mr. Okello, post-intervention interview)

Students also reported noticing a more personalised, student-centric approach in teachers who developed purpose as part of their agentic development as the following comment illustrates:

Ms. Arkwright teaches us more in a one-to-one kind of thing, like she teaches you based on what you know. (Metropolitan, student focus group)

Clear changes in student behaviour in response to the amended practices, in particular the emphasis on eliciting students' personal experiences with science, prompted the teachers to reconsider the nature of their role and practice. Ms de Luca, for example, describes the change to the way she would have normally taught. Her description also suggests a new confidence in her ability indicating a growing mastery in her new sense of purpose:

[Now], when I ask a question it's the immediate reaction where they all just want to turn around and just talk to each other, they want to discuss. Then I know 'okay I've engaged with them,' and like I said previously, usually I would be putting my foot down and getting them to stop and listen. But now if they start talking after I've said something I just back off a little bit just to give them the space to talk, because I know actually it's about the topic and they're engaging into the topic. (Ms. de Luca, post-intervention interview)

Finally, a renewed sense of purpose was evident in the ways that teachers discussed coping with the daily challenges that a job in teaching poses. They noted that the small modifications meant they were still able to cover the necessary content, yet additionally help students see the personal relevance of science. In managing this balancing act, teachers felt happier in themselves as Ms Smith explains:

My challenges are balancing what I'm expected to do to get them to pass [the exams] ... and... still to get them to like science ... and to do it and sort of keep happy in myself. [Science Capital] has definitely helped me find a balance. (Ms. Smith, post-intervention interview)

Mastery

Incidences of increased mastery were evident in the ways in which our teachers assumed a new level of expertise in their practice (van der Heijden et al. 2015) which they were keen to share. Ms de Luca delivered a science capital training session for her colleagues as part of a departmental team meeting. She also shared the approaches with her mentee, a newly qualified teacher, and encouraged her to make notes of successful science capital building pedagogical approaches for her subsequent lessons:

Ms. Norris for example, the NQT, who loves science capital and has tried in every way to embed it into her lessons – if there's something that she felt didn't work she would then come to me going 'I've tried this, that doesn't work, can you find another ... can you ask another question' and [then] we write it in the notes of the lesson.

(Ms. de Luca, post-intervention interview)

Several others similarly sought to share their new knowledge with colleagues. For example, when asked about her experience of the professional development, Ms. Smith acknowledged the development in her thinking and described the ways in which she was sharing her new mastery with colleagues:

I was doing some appraisals this term ... and I remember talking to my colleagues saying 'But you didn't really involve the children, so let's sit down and think how you can do it by using their experiences. Teaching the moon – can you get them to think about an experience that they had with the full moon...'

I'm sort of looking at teaching in other ways ... helping other teachers think. And they're going 'Oh yeah yeah, of course, that's right' (Ms. Smith, post-intervention interview)

Such mastery lies beyond subject knowledge, but rather accords with what Pantić and Florian (2015) describe as 'core expertise' – the knowing, doing and believing – embedded in the inclusive pedagogical approach.

Several teachers noted a change in their regular habits, intimating that the new pedagogical perspectives were now part of their standard professional practice. For example, Ms Randel commented that, because of the regular discussions between herself and the researcher, implementing the approaches were now second nature:

I don't have to spend much time to think about how to include it - it comes straight away, automatically when I'm doing a lesson plan... Because we've been talking, sharing things so much, like you know every time writing a lesson plan, sending it to you, and then it's all automatic. (Ms. Randel, post-intervention interview)

Mr Hobbes' new mastery was clearly recognised by colleagues in his school. At first, several had been sceptical of the new approach, and reluctant to try it in case it added to their workload. They had even challenged his belief in the usefulness of what they perceived to be inconsequential and unnecessary changes to practice. With time, however, Mr Hobbes reported that his colleagues had seen a difference in participation and enthusiasm in his lessons due to his efforts in eliciting the students' experiences as a starting point for each new topic. As Mr Hobbes explains, his colleagues now acknowledge the efficacy of the approach and have asked him for ideas which they could implement in their own practice:

At the beginning of the year [they were] quite hostile, like 'What's the point of this? – wasting time'. I was like 'No it's relevant, it's actually relevant'... But then they looked at me applying it and getting better responses [from students]... and now I know for a fact they come to me for ideas. (Mr Hobbes, post-intervention interview)

Hattie (2012) has argued that the acquisition of mastery is apparent in the increased passion for one's teaching. We would argue that increased passion should be evident to students. Indeed, Ms. Arkwright's students both noticed and appreciated her efforts in linking

science to their everyday experiences, as the following comment from a student focus group makes clear:

Her attitude is more like upbeat, compared to other lessons, [where] it's more like 'do your lesson, do your work!', whereas with her lessons it's more fun [...] We actually use [the lesson content] in our lives, compared to other teachers, they just tell us 'That's it, we move on' whereas she tells us and then we actually learn from it and implement it in our lives. [Mareton, student focus group].

Lastly, it should be noted that the teachers remained committed to the project and that this in itself may be testament to their desire to achieve greater mastery in their work.

Importantly, and as van der Heijden et al. (2015) have argued, in committing to a programme teachers are expressing a desire to keep their role interesting, and moreover, such a desire is a precursor of subsequent change.

Reflexivity

Gomez et al. (2011) have noted the importance of reflexivity for fostering teachers' efforts to reduce exclusion and under-achievement. In a similar tone, Larrivee (2000) argues that thoughtful consideration and systematic self-reflection are essential practices for teachers to become reflective practitioners. The design of our professional development intervention involved partner teachers discussing ways to incorporate science capital approaches with researchers before and after each lesson. This practice facilitated a culture of reflection and thus instances of increased reflexivity were evident across all our data. Levels of reflexivity (Larrivee, 2008), however varied among participants, although all nine developed a degree of 'pedagogical reflection' (ibid.: 343), a level at which teachers reflect on educational goals, and the links between theoretical principles (in our case science capital, equity and social justice) and classroom practice. Ms Enoch, for example, noted that her reflection on her

teaching extended beyond the target class that we regularly observed and had positively impacted her others lessons too:

I think in all my topics now I really think about how I can make it like more related to daily life, bringing a lot of the aspects of the project into ... not just this particular class, but into my other lessons as well. So I try as much as possible to think about how I present the topic to the kids. (Ms. Enoh, post-intervention interview)

A few teachers went further by reaching the stage of ‘critical reflection’ which, according to Larrivee (2008), involves contemplating the moral and ethical implications of classroom practices on students, as Ms Arkwright’s observation illustrates:

I’m much more thoughtful when it comes to planning lessons rather than focusing entirely on the content, thinking about how actually can I engage the students even more, and relating that to their life outside of school, their life in school, their family, their friends, where they live, things in the media, careers. (Ms. Arkwright, post-intervention interview)

These teachers would appear more openly reflective on their assumptions, critical of their own and school practices, and prepared to explore ways to better implement the new approach (Pantić and Florian, 2015).

Autonomy

At first, we struggled to identify increased autonomy amongst our partner teachers. Two of the nine teachers had not personally applied for the professional development programme, and had instead been ‘volunteered’ by their schools. In this way, they began the year with limited autonomy although they soon committed to the programme and took responsibility for any related decision-making. Others, meanwhile, were hindered in their ability to attain greater autonomy by the systemic structures of their school. In particular, teachers with

shared responsibility for a class felt constrained in adopting new practices as they were conscious that this would affect their colleague's plans. Other teachers cited heavy expectations from their heads of department or school as limiting their freedom to enact new ideas. However, during the course of the year, we were able to identify instances whereby our teachers appeared to be using the resources at their disposal to challenge the status quo, inspired by their newly developed, student-centric purpose discussed above. For example, in the quote below, the teacher's autonomy is apparent in her questioning of curriculum-delivery approaches:

The prescribed specification is telling you content, content, content, content, you don't always then have the time to engage with students which is really really frustrating. If they want to ask you a question, even though it's kind of related to the topic, I just think it's important for them to speak - because then they're more likely to want to participate more the following lesson. If you shut the child down because you're like 'I'm sorry I don't have time' I think as a child ... I am empathising as a child ... you'd be a little bit frustrated and you'd kind of be like 'Well I'm not that bothered' (Ms.de Luca, post-intervention interview)

Significantly, some students recognised the increase in their teacher's autonomy in comparison with teachers who were not taking part in science capital building professional development. For example, students participating in a focus group at Mareton were arguably quite critical of another teacher for following a textbook rather than making her own pedagogical choices, as the following quote exemplifies:

[The other teacher] teaches more from like textbook, if you understand what I mean. Like she goes by rules ... she doesn't explain things properly, she just gives you what the book gives you. (Mareton, student focus group)

van der Heijden et al. (2015) note that increased agency is aligned with risk-taking. Le Fevre (2014) has similarly described the place of risk in school innovation, noting the lack of

change in a sample of teachers participating in literacy professional development programme due to fear of potential losses – such as a unruly class; being adversely assessed - outweighing the potential gains. Challenging the status quo is a risk and yet, if it pays off, can afford rewards not only in one's professional practice, but also in underscoring one's belief in oneself and one's agency. Indeed, as the year moved on, and teachers began to see the fruits of their efforts, many sought to innovate more and move away from tried and tested teaching models. Mr. Sharma, for example, sought to challenge the pervading ethos in his school. He explained the situation thus:

The previous head teacher... had a saying about leaving personal stuff outside at the school gates, so leaving everything that's going on outside at the school gates – which is an ethos that we've been doing, we've been promoting within the school since he kind of said it. And I've kind of realised that that's maybe not the best way to do things, and so I've tried to take much more interest in what's going on with the community outside the school. (Mr. Sharma, post-intervention interview)

While all our teachers demonstrated some development in agency as a result of the professional development, some appeared more agentic than others. In our observations of lessons, Ms. Enoh clearly found it difficult to fully implement changes in her teaching, and provided just a few articulations of increased agency during her interviews, at least with respect to building science capital. However, as noted above, an individual's agency is shaped by the structures and cultures in which that individual is situated. The leadership at Ms Enoh's school held particular expectations for classroom behaviour and the structure of lessons which may have prevented Ms Enoh from fully moving away from standardized teaching plans and limited her willingness to elicit contributions of personal experiences from students in case the class become overly loud and excited. In addition, Ms Enoh taught a low-attaining class of students, and had previously articulated her sense of responsibility in

covering the curriculum in order to give her students every chance of success in their exams. In the light of such pressures, it is, perhaps, unsurprising that Ms Enoh did not 'risk' fully implementing the new approaches. Interestingly, Ms Enoh's colleague, Ms De Luca, did seem willing to take risks, and act in ways that contradicted expected teaching protocols. At the beginning of the project she had spoken of her determination to engage students who were actively 'resisting' to engage with science. She said that this was one of the reasons she enrolled in the programme. However, it is also significant to note that Ms de Luca was responsible for a mixed ability group, and thus it is arguable that her faith in her students' ability to perform well academically may have contributed to her greater autonomy to teach as she wished.

Factors Affecting Agency

Our second research question asked which factors promote / constrain teacher agency in the context of science capital building approaches? In reviewing the data and reflecting on the wider structural circumstances faced by each teacher we identified a number of factors affecting their agency. That is, our identification was data-driven, but informed by our review of the literature in which we noted the importance of social, cultural and environmental structures in shaping agency (Barton and Tan, 2010). The key factors identified were the degree of collaboration, the school culture and the effect of others' – colleagues and students – responses to the observable changes in the teachers' practice-

Collaboration

van der Heijden et al. (2015) note that collaboration with others is essential for developing and enacting agency. Similarly, Vähäsantanen (2013) has found that agentic teachers are consciously aware of the need for support from colleagues in order to implement change in their practice. Pantić (2015), meanwhile, notes that higher levels of collaboration in schools

have been shown to indicate higher efficacy and readiness to embrace change. We too found that a sense of collegiality formed the bedrock upon which teachers felt able to reflect, to take risks and to gain new confidence. Teachers from schools with two teachers taking part in the professional development valued collaboration with colleagues and attributed the success of the implementation to having someone with whom to share ideas, as Ms de Luca explains:

Plus it was useful to have a second teacher also involved in it, which was Ms. Enoh. So you had someone else doing it with you and you reflect rather than you're kind of doing it on your own. (Ms.de Luca post-intervention interview)

Teachers who were sole representatives of their school expressed their appreciation for collaboration in two ways. First, they valued working with other teachers from other schools in the two weekend training sessions, as this helped to develop their practice. They also reported that having gained mastery of the approach, they were then able to roll it out across the department and initiate greater collaboration amongst colleagues. As a result, the increased collaboration served to embed the change across the school (Pantić 2015). Indeed, having other colleagues who 'got it' meant that our partner teachers felt more confident in implementing change and exercising their own judgement, even in situations where they were meant to 'follow the script'. One teacher described how he felt able to improvise and teach numeracy during his management performance review because he knew that his colleagues who were also present would see the relevance of his approach:

I was inspired by the science capital stuff, and my physics colleagues saw the relevance and saw the fact that I was explicitly teaching numeracy, explicitly teaching conversions between scales and things like that, but the person observing me for my performance management said 'why are you not teaching Physics, why are you talking with the students about numbers and getting distracted by their questions?' And it took a long time to convince her that this was a valuable way of spending an hour of their time, instead of doing page 37 from the textbook. (Mr. Sharma, post-intervention interview)

We interpret the teacher's confidence here as stemming in part from the knowledge that his colleagues understood his rationale. Such examples of collaboration and collegiality can clearly positively impact teacher agency, and moreover appear to be particularly significant in contexts of increasing performativity demands as we discuss below.

School culture

As Ball (2003) has argued, a performativity paradigm now pervades all aspect of education. Schools and teachers are judged on the success of student examination results, and curricula are thus shaped by the protocols through which 'progress' is assessed. In the face of such pressures, teachers can feel unable to experiment with their teaching. Their purpose as educators can readily become one of equipping students to pass exams. Any departure from the 'sausage factory' model of schooling can be perceived as time-wasting and distracting. The pressure of the performativity culture was recognised by all our partner teachers. While they saw they value of the science capital approach for supporting greater social justice within their classrooms, they did not resist the system expectations that they cover a prescribed body of content, as Ms Smith explains:

So basically you're starting a lesson you don't want to faff around going 'What do you know?' (Ms. Smith, post-intervention interview).

Students too play a role in the performativity paradigm. Indeed, all of our teachers shared the worry of students asking "Why are we doing this, and not preparing for the exam?" This was a joint sentiment in individual teacher-researcher conversations, and was vocalised during the mid-year joint training session. For example, all partner teachers said that they could not try the science capital building approach with their classes in Year 11 (the

final year of compulsory schooling in the UK) as they would need to prioritise exam preparation. However, teachers also seemed aware of the incongruity between their purpose as educators, and their role to ensure that students passed their exams:

It's like [we tell students] 'OK you have to stop thinking about your interests and experiences now [in Y11], you've got to work hard for the exams!' (Mr. Sharma, mid -year teacher workshop)

Buchanan (2015) has noted that while teachers dislike the climate of standardised testing, they nonetheless feel themselves to be professionally validated when their students perform well academically. This contradiction was similarly evident in our group of teachers, with many experiencing a tension between the desire to implement changes in their teaching to support social justice, and the obligations they felt to cover enough ground. While professional development activities could be conceived as part and parcel of the drive for improvement predicated within the culture of performativity, we would suggest that the emphasis on social justice and self-reflection together with the opportunities for collegial working inherent with the science capital approach did at least challenge some systemic structures and ways of working, even if the overarching goal of enhanced performance remained the same. Mr Sharma described the situation as follows:

In the Physics department, we've got that culture now where we find it quite easy for us to go off [the syllabus] spec[ification] and do more science capital.... you don't necessarily need to be teaching on the spec[ification] to improve their ability in physics. (Mr. Sharma, post-intervention interview)

Others' responses to the changes

Throughout our data, we noted that small successes in implementing the approaches sustained the teachers' commitment and prompted further attempts to enact new practices. For some, such successes were not surprising – the proposed changes had resonated with

their existing thinking and they were already poised to explore new ways of working. For other teachers, the proposals suggested by the professional development were initially accepted on trust, and it was only through perseverance that belief in the potential of the approaches grew. Ms de Luca described her experience as follows:

I persevered first of all because from when I was trying to embed science capital I could see that the students were more engaged. So I kind of...I knew that there's something to this, that there is something that is of value. Because you know sometimes with some research it's a lot of ... it's all well and good in theory, but in practice it doesn't always work. So with this when I could see that actually the theory put into practice there is something to it, I thought okay just persevere, keep going with it. (Ms.de Luca, post-intervention interview)

Indeed, feedback from colleagues and, particularly, from students, served to strengthen the teachers' commitment to continue with the approach as these comments illustrate:

People in the school are now aware of it happening in [the] Physics [Department]. They seem to see it as a positive thing. (Mr. Sharma, post-intervention interview)

If students can give you feedback for that, then brilliant. And if they can't or won't, then there's something wrong with it and you need to try another approach (Ms. Arkwright, post-intervention interview)

As noted earlier in the paper, encouraging comments from colleagues served to confirm and underscore the teachers' newly found sense of purpose. Responses from students in the form of increased interest in lessons also served to affirm teachers' confidence in the new approaches. For at least two of the teachers, the increased engagement was palpable as is evident in the following comments:

Physically, when they're talking about something you can see they're happy, they're excited. They want to tell everybody what they've discovered or their answer, or what poster they've

made. So they're eager to share, they're eager to show. (Mr. Okello, post-intervention interview)

I can see it their eyes ... they kind of ... like a meerkat, they pop up and you can see the engagement. (Ms.de Luca, post-intervention interview)

These 'meerkat' moments sealed teachers' confidence in the approach and their determination to persevere.

Discussion

Our analyses indicate that all our partner teachers gained some degree of agency over the course of their year-long participation in the study and associated professional development programme. While some teachers gained more than others, the professional development programme enhanced the capacity of all the teachers to teach in ways that resonate with students' lived experiences. With continued exposure to such teaching, we hope that more students from more diverse backgrounds will come to see science as 'for them', and that their future participation in science (for study, as an occupation, for general citizenship) is possible. We would also suggest that, contrary to the critique by Liu, Miller and Eun Jahng (2016) that university led professional development can hinder the development of teacher voice and agency, our model of partnership working was effective in enabling, to varied extents, increased teacher agency.

To study agency, we borrowed from Pantić's (2015) model comprising the four components of purpose, competency, reflection and autonomy. Pantić's rationale for developing the model was to characterize the nature of teacher agency required to support social justice. Archer's (2000) articulation of transformative agency – the capacity to develop new ideas and new organizational structures – fits well here as a possible definition for the agency characterized by Pantić. We, however, would suggest that in supporting social justice

and more equitable teaching strategies, the teacher agency engendered by initiatives such as our professional development programme, may be better described as ‘critical teacher agency’. That is, the capacity to act in ways that provide opportunities for all learners to participate and self-identify with the subject, to broaden what counts as both learning and engagement, and to provide education that is relevant to learners’ lives (see for example the pedagogy described in Huffling et al. 2017; see also Zimmerman and Weibler 2017). In defining critical teacher agency thus, we build upon Barton and Tan’s definition of student agency as the use of science by students to ‘develop their identities, to advance their positions in the world and/or to alter the world toward what they envision as being more just’ (2010:195).

In fostering critical teacher agency, discussions around the purpose and meaning of schooling will inevitably open up. As Biesta et al. (2015) have argued, current policy discourses and systems of accountability are narrowly conceived and short-term in nature, and tend to focus solely on student attainment as determined by externally set measures. In contrast, through the application of critical teacher agency, a wider vision of education becomes tenable. Of course, increased agency is not a silver bullet. As Dover et al. (2016) have found, even justice-orientated teaching programmes are obliged to enact social justice within the context of performativity and standards-driven schooling. However, we assert that the support of critical teacher agency with its component parts of greater reflexivity, mastery, renewed sense of purpose, and autonomy is essential if we wish to retain teachers in the profession. As Buchanan has argued:

If teachers don’t feel like they have the opportunity to engage with authentic human experience that develops their students as emotional, social, intellectual and moral people they may not stay in the classroom and students will only learn the material that helps them succeed on the tests. (2015: 715).

Indeed, as reported above, many of our teachers felt constrained by the pervading

accountability paradigm present in their schools. While the teachers engaged in reflection, and reconsidered their purpose as educators, their autonomy to change their practices was limited: the wider structures and systems of their institutions curtailed their nascent agency. Giddens (1984) has argued that there is a limit to which subordinate agents can influence the wider field, either individually or collectively. This is particularly true in instances when the field favours performance and attainment. To achieve greater agency, it follows that the field needs to change especially with respect to the ways in which success in teaching is defined.

A further structural constraint to agency comes in the form of student behaviour. Several of our partner teachers were responsible for classes in which students were regularly disruptive, and indeed they found it difficult to implement any changes to their teaching practice which would not adversely affect the delicate balance of teacher–student relations. Over several years, students had grown accustomed to particular teacher practices and some may have been unsettled by their teacher’s adoption of science capital approaches. Change takes time, and thus we accept that the development of agency in settings characterised by challenging students may require ongoing support over a time period longer than a single year. Indeed, we acknowledge that our data only extends for the year in which teachers worked closely with researchers and were regularly observed no doubt prompting greater effort and implementation of the new practices and concomitant increases in expressions of agency as a result. To determine whether the science capital approach is successful in enabling increased teacher agency over the longer term will be a focus of future work examining the impact of the Enterprising Science project as a whole.

Conclusion

The discussion above has implications for wider educational practice and policy. Clearly, there is a need to broaden what counts as ‘success’ and to support teachers in their

adoption of more equitable practices. Rather than valuing students' exam scores as indicators of both students' and teacher performance and progress, we suggest that it may be more socially just to measure developments in critical teacher agency, and ensure that it is fostered throughout the teacher 'professional continuum' (McMahon, Forde and Dicson, 2015).

Relatedly, measures of agency could similarly provide a useful reference for establishing the success of professional development initiatives. For example, Guskey's (2000) widely-used framework for evaluating professional development examines success at five incremental levels: the participants' affective reactions to the course; the participants' learning; the extent and support for change in the organisation; the participant's use of new knowledge and skills; and extent of impact on student learning. While highlighting the importance of teacher mastery, and the role of structural factors such as organisational support, the agency components of autonomy, reflexivity and purpose are not addressed by Guskey's levels. We therefore propose that a focus on agency could be an additional lens through which to examine the efficacy and sustainability of professional development initiatives.

We end this paper by applauding the efforts of our partner teachers who, despite situational constraints and difficulties, reflected on their purpose and practice as teachers, gained new skills, and developed greater autonomy in using the resources available to them. Most significantly, these teachers challenged existing norms to teach in more equitable ways. In short, they displayed critical teacher agency which we sincerely hope they will be able to develop further as they continue to apply the science capital pedagogical approach.

References

- Archer, Margaret Scotford. (2000). *Being human: the problem of agency*. Cambridge, U.K.; New York: Cambridge University Press.
- Archer, Louise, Dawson, Emily, DeWitt, Jennifer, Seakins, Amy, and Wong, Billy (2015). "Science Capital": A Conceptual, Methodological, and Empirical Argument for Extending Bourdieusian Notions of Capital beyond the Arts. *Journal of Research in Science Teaching* 52 (7): 922–948. Doi: 10.1002/tea.21227
- Archer, Louise, Dewitt, Jennifer., Osborne, Jonathan., and Wong, Billy. (2012). Science aspirations, capital, and family habitus. How families shape children's engagement and identification with science. *American Educational Research Journal*, 49(5) 881–908
- Ball, Stephen J. (2003). The teacher's soul and the terrors of performativity. *Journal of Education Policy*, 18(2), 215-228. doi: 10.1080/0268093022000043065
- Bandura, Albert. (2001). Social Cognitive Theory: An Agentic Perspective. *Annual Review of Psychology*, 52(1), 1-26. doi: 10.1146/annurev.psych.52.1.1
- Barton Calabrese, Angela, and Tan, Edna. (2010) We Be Burnin'! Agency, Identity and Science Learning. *Journal of the Learning Sciences*, 19:2, 187-229 doi: 10.1080/10508400903530044
- Biesta, Gert, Priestley, Mark, and Robinson, Sarah. (2015). The role of beliefs in teacher agency. *Teachers and Teaching*, 21(6), 624-640. doi: 10.1080/13540602.2015.1044325
- Biesta, Gert, and Tedder, Michael. (2007). Agency and learning in the lifecourse: Towards an ecological perspective. *Studies in the Education of Adults*, 39(2), 132-149. doi: 10.1080/02660830.2007.11661545
- Buchanan, Rebecca. (2015). Teacher identity and agency in an era of accountability. *Teachers and Teaching*, 21(6), 700-719. doi: 10.1080/13540602.2015.1044329
- Davies, Bronwyn. (2010) The struggle between the individualised subject of phenomenology and the multiplicities of the poststructuralist subject: the problem of agency. *Reconceptualizing Educational Research Methodology*, 1(1), 54-68. doi:10.7577/term.171
- Dover, Alison, Henning, Nick, and Agarwal-Rangnath, Ruchi. (2016). Reclaiming agency: Justice-oriented social studies teachers respond to changing curricular standards. *Teaching and Teacher Education*, 59, 457-467. doi: <http://dx.doi.org/10.1016/j.tate.2016.07.016>
- Elias, Peter., Jones, Paul., and McWhinnie, Sean.(2006) *Representation of ethnic groups in chemistry and physics*. London. Royal Society of Chemistry and Institute of Physics.
- Emirbayer, Mustafa., and Mishe, Ann. (1998). What is agency? *American Journal of Sociology*, 10(4), 962 – 1023
- Eteläpelto, Anneli, Vähäsantanen, Katja, Hökkä, Päivi, and Paloniemi, Susanna. (2013). What is agency? Conceptualizing professional agency at work. *Educational Research Review*, 10, 45-65. doi: <http://dx.doi.org/10.1016/j.edurev.2013.05.001>
- Florian, Lani. (2009). Preparing teachers to work in 'schools for all'. *Teaching and Teacher Education*, 25(4), 533-534. doi: <http://dx.doi.org/10.1016/j.tate.2009.02.004>

- Freire, Paulo. (2000). *Pedagogy of the oppressed* (30th Anniversary Edition ed.). New York: Continuum.
- Giddens, Anthony. (1984). *The constitution of society: Outline of the theory of structuration*. Cambridge: Polity.
- Hattie, John. (2012). *Visible learning for teachers: maximizing impact on learning* (Vol. Abingdon; New York, N.Y.): Routledge.
- Huffling, Lacey, Carlone, Heidi, and Benavides, Aerin. (2017). Re-inhabiting place in contemporary rural communities: Moving toward a critical pedagogy of place. *Cultural Studies of Science Education* 12 (1): 33-43. doi:10.1007/s11422-016-9756-2
- King, Heather, Nomikou, Effrosyni, Archer, Louise, and Regan, Elaine (2015). Teachers' understanding and operationalisation of 'science capital'. *International Journal of Science Education* 37 (18): 2987–3014. doi:10.1080/09500693.2015.1119331
- Larrivee, Barbara. (2000). Transforming Teaching Practice: Becoming the critically reflective teacher. *Reflective Practice*, 1(3), 293-307. doi: 10.1080/713693162
- Larrivee, Barbara. (2008). Development of a tool to assess teachers' level of reflective practice. *Reflective Practice*, 9(3), 341-360. doi: 10.1080/14623940802207451
- Lasky, Sue. (2005). A sociocultural approach to understanding teacher identity, agency and professional vulnerability in a context of secondary school reform. *Teaching and Teacher Education*, 21(8), 899-916. doi: <http://dx.doi.org/10.1016/j.tate.2005.06.003>
- Le Fevre, Deidre. (2014). Barriers to implementing pedagogical change: The role of teachers' perceptions of risk. *Teaching and Teacher Education*, 38, 56-64.
- Liu, Katrina, Miller, Richard, and Jahng, Kyung Eun. (2016). Participatory media for teacher professional development: toward a self-sustainable and democratic community of practice. *Educational Review*, 68(4), 420-443. doi: 10.1080/00131911.2015.1121862
- McMahon, Margery, Forde, Christine, and Dickson, Beth. (2015). Reshaping teacher education through the professional continuum. *Educational Review*, 67(2), 158-178. doi: 10.1080/00131911.2013.846298
- Nomikou, Effrosyni, Archer, Louise, and King, Heather (2017). Building science capital in the classroom. *School Science Review*, 98 (365): 97-103
- Pantić, Nataša. (2015). A model for study of teacher agency for social justice. *Teachers and Teaching*, 21(6), 759-778. doi: 10.1080/13540602.2015.1044332
- Pantić, Nataša, and Florian, Lani. (2015). Developing teachers as agents of inclusion and social justice. *Education Inquiry*, 6(3), 333-351. doi: <http://dx.doi.org/10.3402/edui.v6.27311>
- Sannino, Annalisa. (2010). Teachers' talk of experiencing: Conflict, resistance and agency. *Teaching and Teacher Education*, 26(4), 838-844. doi: <http://dx.doi.org/10.1016/j.tate.2009.10.021>
- Vähäsantanen, Katja. (2013). *Vocational teachers' professional agency in the stream of change*. Jyväskylä: Jyväskylä University Printing House.
- van der Heijden, Monique, Geldens, Jeannette., Beijaard, Douwe., and Popeijus, Herman. (2015). Characteristics of teachers as change agents. *Teachers and Teaching*, 21(6), 681-699. doi:

10.1080/13540602.2015.1044328

van Oers, Bert. (2015). Implementing a play-based curriculum: Fostering teacher agency in primary school. *Learning, Culture and Social Interaction*, 4, 19-27. doi:
<http://dx.doi.org/10.1016/j.lcsi.2014.07.003>

Zeichner, Ken. (2009). *Teacher education and the struggle for social justice*. New York ; London: Routledge.

Zimmerman, Heather and Weible, Jennifer. (2017). Learning in and about rural places: Connections and tensions between students' everyday experiences and environmental quality issues in their community. *Cultural Studies of Science Education*, 12 (1): 7-31 doi:10.1007/s11422-016-9757-1