
Special issue: *Culturally responsive STEAM education*

Research article

Towards justice-oriented science teaching: examining the impact of the science capital teaching approach on teachers

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Submission date: 17 August 2023; Acceptance date: 10 October 2023; Publication date: 29 November 2023

How to cite

Nag Chowdhuri, M., King, H., Godec, S. and Archer, L. (2023) 'Towards justice-oriented science teaching: examining the impact of the science capital teaching approach on teachers'. *London Review of Education*, 21 (1), 37. DOI: <https://doi.org/10.14324/LRE.21.1.37>.

Peer review

This article has been peer-reviewed through the journal's standard double-anonymous peer-review process, where both the reviewers and authors are anonymised during review.

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London Review of Education is a peer-reviewed open-access journal.

Abstract

While several initiatives for justice-oriented pedagogies have been developed and implemented over the years, there is limited understanding of the ways in which teachers, and their practice, are impacted by these. This article presents data documenting the impact of a pedagogical approach – the science capital teaching approach – on a cohort of teachers. The approach, developed over a period of six years working in close partnership with primary and secondary teachers in England, aimed to support teachers to move towards more equitable and socially just pedagogical practice. This article explores the empirical impact of the approach on teacher practice. The data set comprises the experiences of 43 secondary and 20 Primary school teachers from different geographical

regions in England, covering both rural and urban schools. Qualitative data include teacher interviews, observations and discussions and indicate that implementation of the approach resulted in a range of changes: (1) a deepened understanding of, and reflection on, issues of power and equity; (2) greater sharing of authorial roles with students; and (3) stronger relationships of trust between students and teachers. The article concludes by arguing that the implementation of the science capital teaching approach has had a positive effect on teachers and has supported their practice of justice-oriented science teaching.

Keywords science education; secondary; primary; pedagogy; social justice; research–practice partnership

Introduction

Justice-oriented science pedagogies seek to counter the marginalisation of underserved children within formal science education. This need has been well established, particularly as a way of repaying the debt for the historical injustice towards marginalised students within contexts of the Global North (Ladson-Billings, 2006). Consequently, since the start of the twenty-first century, interventions have been developed at the levels of pre-service teacher education and in-service professional development, to support teachers' understanding, development and enactment of justice-oriented teaching practices (Gist et al., 2019; Ramirez et al., 2016). Many of these pedagogies are informed by the arguments and insights developed by scholars working on culturally relevant, responsive and/or sustaining pedagogies (Ladson-Billings, 2021). In this article, we refer to such initiatives as justice-oriented teaching.

Despite efforts and intentions to implement justice-oriented initiatives, differences in operationalisation and subsequent lack of impact monitoring have led to inconsistent and limited understanding of their impact on teachers. This is for multiple reasons. First, a large number (if not the majority) of interventions focus on pre-service teacher education and student-teachers' development of learning about such pedagogies (Fortney and Atwood, 2019; Reagan and Hambacher, 2021), and thus an understanding of impact on everyday teaching is less explored. Second, within in-service interventions, there is no one way of capturing effect. For example, Bottiani et al. (2018) found that of 10 studies that cited the use of justice-oriented pedagogies, each conceptualised the approach and measured the impact in a different way. While some studies viewed justice-oriented pedagogy through the lens of school improvement, others were concerned with the ways in which students' funds of knowledge were recognised, and still others focused on pedagogical approaches in the classroom. Bottiani et al. (2018) thus concluded that empirical research examining the impact of interventions to improve justice-oriented teaching is in a nascent stage. Furthermore, they highlighted the difficulty of such an endeavour, noting the challenge in responding to 'conceptual, methodological and practical' complexities (Bottiani et al., 2018: 380). In an attempt to cut through the complexity, and with a view to documenting the implementation of our own justice-oriented approach – the science capital teaching approach – we focus our analysis on the impact on in-service teachers and their practices. Furthermore, we work on the assumption that in changing teachers' practice, developments in students' learning experiences inevitably follow. Specifically, we ask: What are the impacts of implementing a justice-oriented pedagogical approach on in-service teachers in primary and secondary schools in England?

In this article, we begin by reviewing the literature discussing the implementation and evaluation of justice-oriented teaching, before turning to a description of the science capital teaching approach. We then present and discuss our data. Finally, we summarise the key impacts of the approach and discuss the implications for teachers.

Literature review

As noted above, the field of science education lacks a consistent measure for determining the effect of justice-oriented pedagogies, which in turn may contribute to inconsistencies in the operationalisation of

such approaches. For example, a study by Debnam et al. (2023: 10) exploring practices at a classroom level found that ‘there may not be one universal way to implement culturally responsive practices in the classroom’. Furthermore, the authors recognise that ‘enactment’ of pedagogies that are culturally responsive can go beyond frameworks defined by scholars. Indeed, this is a common struggle or challenge that comes up within the education literature related to the difficulty of translating ideas into practice. For example, Brown et al. (2019), exploring teachers’ knowledge and practices around justice-oriented practices in science and mathematics classrooms, found that teachers often experience difficulties in translating their ideas and intentions into practice. However, while they start with superficial translations, over time and with further training teachers become more confident in developing more culturally relevant and meaningful problem-solving in classrooms.

Apart from the difficulty of translation, Debnam et al. (2023) highlight another struggle that teachers commonly encounter. This relates to the differentiation between common teaching practices and justice-oriented practices, and the overlap between the two. Delineating this distinction is crucial, as it helps to identify what it is within a particular practice that makes it justice-oriented. For example, caregiver and home communication is key within any teaching practice, but how this extends within justice-oriented teaching in terms of tailoring to students’ lived experiences is a key point of difference. Debnam et al. (2023: 5) discuss the importance of ‘straddling the line’ between common and justice-oriented practices by getting to know the students, building relationships, tailoring communications and discussing culture in class. Such steps, they contend, can help to address the inequities within education.

Meanwhile, Kolovou (2023) similarly notes the importance of rapport building, integrating student identities within teaching and shifting authority roles between teachers and students. To discern impact, Kolovou looks for indications of critical consciousness among the student body, including increases in sociopolitical awareness and instances of students being actors of social change. Yet the literature also highlights that justice-oriented pedagogies take time to be fully embedded into practice, and thus any measurement of change is difficult to obtain (Romijn et al., 2021). Moreover, as Pagán (2022) has argued, the sustainable enactment of justice-oriented approaches, more particularly, often encounters both structural and individual barriers. The actions identified by Debnam et al. (2023) and Kolovou (2023), in the context of straddling the line between common and justice-oriented practices, resonate with our own work investigating equitable practice in science education. In what follows, we describe the science capital teaching approach.

Science capital teaching approach

The science capital teaching approach was developed in partnership with researchers and teachers for six years, between 2015 and 2021. The development was supported by two tranches of funding, with the second project being affected by school closures during the years of the Covid-19 pandemic, between 2020 and 2021. During the two project periods, we, researchers and teachers, repeatedly tested and refined the emergent ideas. Sharing our thinking with the broad team and with other educators outside the projects provided a further prong to the refinement process, while determining ways to best communicate the ideas inherent in the approach for publication in secondary (Godec et al., 2017) and primary (Nag Chowdhuri et al., 2021) handbooks also helped us to identify and clarify the approach’s key underpinning elements.

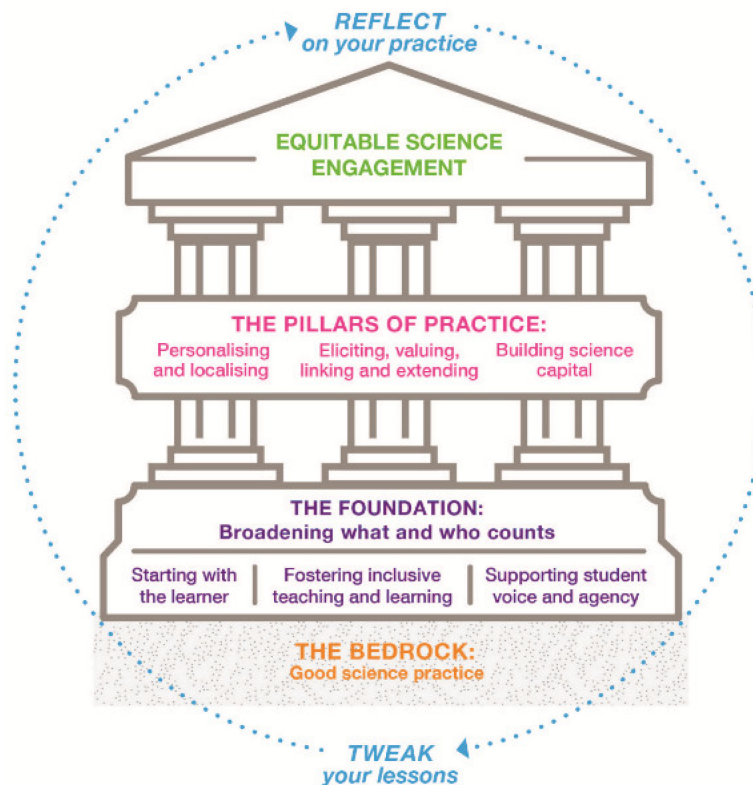
The approach was conceptualised through a Bourdieusian lens of capital and field (Bourdieu, 1977). This lens highlighted the significance of the field in enabling or constraining students’ application of *science-related capital* (Archer et al., 2015, 2018). Thus, the teaching approach supported teachers to critically question the dominant (inequitable) *field* of science education, and thereafter apply justice-oriented teaching within their everyday practice to create a more even playing field for students. Four key justice-oriented ideas underlie the science capital teaching approach. These are: (1) recognising and disrupting dominant power relations and forms of representation within science teaching and learning; (2) using culturally relevant and assets-based teaching approaches; (3) developing trust and care between teachers and learners; and (4) supporting students’ agency and social action through science teaching and learning. These four principles delineate the pedagogical nature of the approach and combine both a challenge to dominant power relations in the science education field and the promotion of asset-based teaching pedagogies, developed by scholars of culturally relevant,

sustaining and responsive pedagogies. Finally, the science capital teaching approach supports teachers in developing trusting and caring relationships with their learners, in turn enabling students to gain more agency in their science learning, with the aim that science becomes a vehicle for social action and change in learners' lives.

We have visualised the approach as a temple comprising strong foundations built on a firm bedrock of good science teaching practice (see Figure 1). These foundations support key pillars, with the outcome being justice-oriented practice. However, it is important to note that the temple exists in a cycle of reflection – the foundations, the pillars and the outcomes are continually revisited to ensure that the edifice remains as strong as it can possibly be. The foundations consist of three elements: (1) starting with the learner; (2) fostering inclusive teaching and learning; and (3) supporting student voice and agency. The foundations then support three pillars: (1) personalising and localising; (2) eliciting, valuing, linking and extending; and (3) building science capital.

As noted earlier, the science capital teaching approach evolved over an extended period and experienced different emphases at different times. For example, at the end of the first funded period, which focused on secondary practice, we had not delineated the three elements of the foundation (Godec et al., 2017; Nag Chowdhuri et al., 2021). The need for greater explication emerged over time, as we realised that some teachers were focusing much more on the pillars than on the fundamental idea or vision of broadening what counts as science. The evolution of the approach reflects the iterative testing and implementation of ideas in schools across entire school years. Teachers experimented by making small changes to their regular practice and then, together with researchers observing the class, reflected on the outcomes. Initial steps were often the hardest, but in adopting small tweaks over time, teachers became more confident in their practice and recognised the need to change the field, rather than change the student (Godec et al., 2018; King and Nomikou, 2018; King et al., 2015). Moreover, the teachers were key in helping to translate the more theory-driven articulations of the approach into practice-driven phrasing.

Figure 1. Model of the science capital teaching approach (Source: Nag Chowdhuri et al., 2021: 7)



Researching the impact of the science capital teaching approach on teachers and their practice

Our research exploring the impact of the science capital teaching approach spanned six years (2015–21), across two funding cycles. In the first period (2015–18), we worked with secondary and middle school teachers. In the second period (2019–21), we worked with primary school teachers.

Between 2015 and 2018, the project was implemented across six secondary schools in the North of England and in different parts of London. The schools served medium- to low-income communities, and thus represented some of the marginalised learners that our wider research programme sought to support. Most of our partner teachers implemented the approach with the students in Key Stage 3 (that is, the first two or three years of secondary schooling).

In the second period, between 2019 and 2021, we worked with primary and early years teachers. Using the funders' network (who worked in the field of science professional development), 10 schools catering to underserved communities were chosen. The schools were recruited such that we could capture experiences of a diverse range of schools, as well as communities representing different regions of England. Two teachers from each school participated in the research – such that one was a mid-career subject specialist teacher and one was an early career subject non-specialist teacher. It is important to note that this period of the project was impacted by Covid-19, yet we were able to conduct online interviews and workshops with the teachers and to conduct classroom observations prior to the lockdown.

In both project cycles, teachers enacted the approach through a series of tweaks and changes to their regular practice. Researchers observed the tweaked lessons and engaged in post-lesson reflective discussions with teachers to determine next steps in practice. Below, we discuss our teacher-focused data points in greater detail.

Formal teacher interviews

To examine the potential impact of the approach, teachers participated in semi-structured interviews at the end of the academic year. The interviews covered details of the implementation process (reported in internal project evaluations), perceived impact on their teaching practice and their perceptions about the impact of the approach on students' participation, behaviours and attitudes. As shown in Table 1, for the secondary phase, 13 secondary science teachers participated in the end-of-phase interviews (2017), with each interview lasting between 30 and 45 minutes. For the primary phase (2021), 17 primary school teachers (in pairs) participated in interviews lasting for between 45 and 60 minutes each. Broad and open questions were used to examine the impact of the approach (on student engagement, equitable practice and any other outcomes). Questions included:

- Could you briefly summarise your implementation of the approach, and any outcomes that followed?
- Could you tell us about any aspect of your teaching that you feel has evolved after this experience?
- How do you think the changes in your practice have affected student engagement with science?
- How has your use of the approach enabled more equitable science teaching/learning/engagement in your class?

Informal reflections and discussions

As highlighted above, one of the key aspects of the implementation of the approach was the tweaking–reflecting cycle. Teachers would tweak their lesson plans, trial the approach and then reflect on their practice building on three key prompts – what went well in the lesson, what were the challenges and ideas for how the lesson could be further improved. Some teachers also completed reflective diaries. These sources of reflection were then discussed with researchers during regular meetings. In total, this article reports data from about 70 of these discussions with secondary school teachers and about 40 discussions with primary school teachers.

Table 1. Overview of data collection

	Secondary	Primary
Number of teachers	43	20
Formal teacher interviews	13	10
Informal teacher reflections	70	40

Data analysis methods

Analysis of the interview transcripts involved identifying data on different aspects of changes in teacher practice, processes and challenges of implementation, and the impact of the approach (Ryan and Bernard, 2003). As noted above, interview questions were broad and open (that is, guided by the aim of better supporting marginalised students to engage with science in more equitable ways). The analysis identified examples of changes to teacher practice that we see as indicating a move towards more justice-oriented pedagogy, which in turn affords an effect on students. Our analysis was deductive, using the framework of justice-oriented pedagogy and its four elements as our starting point, exploring how and to what extent these manifested in teachers' practice following their implementation of the science capital teaching approach.

We recognise that because our qualitative data consist of interviews with teachers, there are limitations in our interpretations of the impact. In utilising teachers' views of the impact on their own practices, we also acknowledge that there are possibilities of biases (Herrington et al., 2016). Nonetheless, we suggest that the teachers' views afford a valuable insight into the nature of the classroom environment shaping the experiences of the students. In addition, our aim was not to conduct a fidelity evaluation between the ideas of the model and teacher practices, but rather to identify what aspects of justice-oriented thinking seemed to resonate with the teachers as they used the approach.

Different researchers worked on the partnership projects with teachers that led to the development of the approach. MNC (South Asian, researcher) was the lead researcher for the primary school research project, and HK (White, European, researcher) was the lead researcher for the secondary school project. SG and LA (both White, British, professors) have been involved throughout the six years and have overseen the project, its development and operationalisation. In addition, five more researchers supported the project (data collection, dissemination) in different stages but were not involved in the data analysis or writing for this article. The analysis for this article was conducted over an extended period by all four authors and involved negotiations, discussions and meaning making as a collective (Frost et al., 2011). Interpretations of the data were thus discussed as a group, and further informed by our reading of justice-oriented literature. In addition, the authors brought together their varied perspectives (for example, sociology of education, teacher education, formal and informal science teaching), providing a breadth of insight and classroom-based understanding to inform our interpretations.

Note that all the data from the teachers included in this article have been anonymised, and pseudonyms have been used. Furthermore, appropriate consent was sought, and ethical guidelines were followed throughout the research using the ethical framework of the British Educational Research Association. The study also gained ethics approval from the universities where the research team were based.

Impact on teachers: towards justice-oriented practices

Understanding of inequalities and addressing dominant power relations in science teaching

At the core of all justice-oriented approaches to education lies the aim of redressing extant power relations which dominate teaching and learning in the classroom. The science capital teaching approach challenges dominant structures and representations of science through an emphasis on broadening what and who counts in science learning (see Figure 1).

During interviews and in informal conversations, both secondary and primary school teachers acknowledged a new and much deeper understanding of the power relations in their classes, and came to recognise the inequalities reproduced through their own teaching practices. For instance, primary school teacher Ms Wilson reflected on whether she unconsciously privileges some children over others: 'we could say, "oh, that child is really science-y", but it's probably because they're the loudest. So, it is to do with our perception and expectation as much as everything else.' Similarly, Ms Alcott critically reflected on what 'counted' in her classroom:

I didn't realise that I was being exclusionary. I thought that if a few people were giving the answers and the lesson felt like it was flowing, then I was doing a really good job. But it was the stopping and thinking actually, 'Oh, it's the same four people every lesson that are giving me answers.' (Ms Alcott, primary school teacher)

The privileging of loud and vocal students in the science classroom has been discussed in the literature, which suggests that teachers often relate these sorts of behaviours and *performances* to being a *good science student* (Carlone et al., 2015). Such loud and vocal performances within a science classroom can be interpreted as *muscular intellect*, typically enacted by White, middle-class boys, making it more challenging for students from other backgrounds to enact celebrated performances (Archer et al., 2019). We interpret the teachers' *recognition* of specific power relations (of what tends to be valued and what not; what is celebrated and what is not) and *acceptance* of their own role in reproduction of science-related inequalities as critical steps towards a more justice-oriented practice. Furthermore, the approach, with its emphasis on fostering inclusive teaching and learning, provided a framework for the teachers to reflect on these practices through an equity lens. Teachers thus took active steps to promote and celebrate the contributions of children who were traditionally less vocal, and/or whose voices and lived experiences were less commonly shared. Teachers also sought to value contributions even when they were not expressed using canonical examples or ways of speaking.

Teachers felt that their questioning of power relations (who counts in science) impacted the ways students perceived school science and who gets to do science or become a scientist. For instance, teachers mentioned that they observed more students perceiving science as accessible to them:

They [students] had seen science as something that's so far away from what they're capable of doing. And the science capital teaching approach has given them the idea that it's not, that it's something that they can do, like anybody ... A student yesterday said, 'Anyone can be a scientist, Miss, anyone can.' And one of the girls even said to me, 'I actually thought scientists wore lab coats, white crazy hair' ... it's challenging what they see as a scientist ... and I think they're able to see science as a potential career. (Ms Thornhill, secondary teacher)

However, teachers also acknowledged that these power dynamics cannot be flipped simply through one lesson or a singular effort. Indeed, the recognition of inequalities within science teaching and learning can be a complex process for teachers trying to use social-justice-oriented teaching and learning, and it takes time. This is encapsulated by primary school teacher Ms Rizwan's recognition that greater consciousness is key:

While planning every lesson, I am now thinking, 'Am I discriminating against anybody?' I don't want anybody to feel like they can't access this learning for any reason. It's not perfect and I am making mistakes, but I'm more conscious of them. For me, it's being more conscious of providing a lesson that's not only engaging but levelling the playing field as much as possible.

The 'consciousness' Ms Rizwan talks about resonates with the ideas of Freire's (1973) *critical consciousness*, which encourages a critical reading of the world. Using the science capital teaching approach, teachers seem to be on the pathway to a greater criticality, focusing on and (to various degrees) acting against unequal power relations within their classrooms.

While enacting the approach, teachers also encountered difficult issues around power and privilege dynamics which are structural in nature. For example, when attempting to personalise and localise (first pillar, see Figure 1) and inviting students to share their experiences, issues of unequal wealth and privilege become paramount, as primary school teacher Ms Walker explained:

Sometimes the sharing from home can have the opposite effect [to justice-oriented pedagogy]. We were talking about personal electronic items in their homes, and that really highlighted the difference between the ones that have the TV, the PlayStation or the Xbox and those who didn't. It is very hard, but as long as you're aware, you can try and balance it out. Because you know so much about the children that you know which ones to ask if it's getting a bit, 'Oh, we've got this and this.' Then you know who to ask to balance it out for those that don't.

In this instance, we can see Ms Walker finding it difficult to address the issues that may arise when bringing students' lives into the classroom. Ms Walker's description also challenges the view of a classroom being culturally neutral with no power dynamics and further highlights the larger socio-economic inequalities that teachers must navigate. The move from power blindness to social justice means recognising and exposing differences. Our observations include many examples of teachers attempting to straddle the difference. Our reflections note that many found this process uncomfortable. Such feelings resonate with other studies that find that sitting with discomfort around equity and/or justice is an important stepping stone towards more equitable practice (Nag Chowdhuri and Archer, in press).

Sharing power with students and supporting student agency

Highlighting the contribution of all students is an important and necessary step towards creating a more justice-oriented classroom in which students feel comfortable and able to enact agency to engage. As discussed by Arnold and Clarke (2014), one way of supporting agency is to share the authorial role within science lessons. In implementing the science capital teaching approach, teachers shared the authorial role by positioning students as agentic in the learning of the class.

For example, teachers reported the value of letting children take a more active role in their lessons. Primary school teacher Ms Parker commented that as she embedded the approach into practice, she had learned to trust the students and their ideas: 'A lot of the times now, the children themselves can come up with contexts, as they are starting to link science to things that they are aware of ... it's quite surprising how much the children can actually do that for you within the lesson.' Adopting a more open ethos and sharing control and responsibility with students lessened the pressure that teachers often put on themselves to come up with all the ideas and all the answers. Sharing greater authority with students is another example of 'straddling the line' (Debnam et al., 2023: 5), and an indication of the move towards a more justice-oriented teaching culture.

Teachers further explained that they were able to foster student agency by celebrating the varied assets that children held, and using these to help individuals form meaningful connections between school science and their own lives. The technique seemed to work particularly well with children from underserved communities. For example, primary school teacher Ms O'Connors spoke about Robert, who was in foster care, and due to his difficult life situation appeared often to struggle at school. To encourage an interest in science, Ms O'Connors rearranged her lesson on sound, to centre the topic on drumming – a hobby of Robert's:

So, when we were doing our sound topic, I tried to base quite a lot of it around drumming so that he [Robert] could be very much involved and take the lead. He really, really got a lot out of it, and there was lots of communication between home and school with that. So that was a really good experience for him.

(Building) stronger relationships of trust with students

Teachers' increased keenness to include (diverse) student voice in the science lessons led them to make an active effort to learn about, and build relationships of trust with, students and their families. For instance, primary school teacher Ms Lessing commented on how she not only valued students' life experience within science lessons, but was also 'much more attuned to picking up any comment that a child makes', even in out-of-lesson settings. She further talked about how these comments then came in useful and helped in science lessons: 'I can kind of squirrel it away, so I know that when we are doing that in science, I can ask that child and say, "Oh, you've got a bird at home, tell us about birds."' Similarly, primary school teacher Ms Walker recalled an example whereby, when studying the topic of materials used in making shoes, she was able to link the lesson to children's interests: 'Oh, I know that that child did ballet outside of school and went to ballet classes, so I was able to ask her about the material in ballet

shoes.’ She noted that helping children realise that there are links to their own lives and their parents’ lives made science lessons more meaningful. Such a strategy of building relationships, and using the student–teacher interaction as an arsenal to leverage in science lessons, has been seen in other studies where teachers implement justice-oriented approaches (Brown and Crippen, 2016; Johnson and Marx, 2009).

Relationship and trust building were also reported by the secondary school teachers. For example, Ms Clarke noted, ‘You’ve got to have that relationship with the kids and know that information about the children.’ The impact of the approach on relationships was also stated by Mr Chadwick:

They’ve [students] seen that I care about them enough to put more effort in. They’ve been more engaged because they feel like I am more interested in them as people. Because I know more about them, I know more about their life and their home background.

This is echoed by Ms Douglas, who found that showing that she was ‘bothered’ about the lived experiences of students’ lives reaped dividends:

Showing them that I am bothered about what they do outside of school, and sort of understanding where they’re coming from and what they do know is really important. Instead of saying, ‘Right, this is the lesson, learn this’, I’m now saying, ‘Well, what do you know about it, what have you seen, what can you tell me?’ This engages them more because they were able to tell me stuff about something that they felt they were going to learn a bit more about. And, yeah, I can measure that in terms of the quality of responses and also the amount of people volunteering answers.

In sum, in respecting and building on students’ own experiences, teachers were able to gain students’ trust. In turn, increased trust in the classroom can result in students finding science learning to be more enjoyable and less threatening: they feel comfortable in such environments, and able to learn.

Discussion: possibilities and challenges of the science capital teaching approach

This article presents the results of the impact of a long-term enactment of a justice-oriented science capital teaching approach, which was developed by researchers and teachers in primary and secondary schools. It reports positive impacts on teachers towards justice-oriented teaching, while also considering the important challenges that need to be considered, as we strengthen the research base on justice-oriented in-service science teaching in England.

The findings above illustrate that while enacting the science capital teaching approach, teachers came to recognise and question inequalities and power dynamics within their science classrooms. Consequently, they made efforts to amend their practice, changing the traditional structures of the science classroom. Teachers progressed with sharing power and authority with students, inviting them to be active players in their learning and valuing their varied knowledge and experience (broadening what counts), which helped support their voice and agency. Finally, through implementing the science capital teaching approach, teachers developed stronger relationships of trust with their students, which also further supported their justice-oriented pedagogy.

Importantly, through the process of implementing science capital teaching approach, teachers also critically reflected on wider issues at play in schools and began to question larger issues of socio-economic inequalities that affect students’ engagement, as well as the ways in which justice-oriented approaches may (or may not) support all students. Participating teachers raised issues around the need to carefully consider whether a well-intended classroom activity, such as around sharing knowledge and experience of home electronics, might inadvertently surface further inequalities. Indeed, this finding resonates with previous research studies, which argue that teachers often are not prepared well enough to deal with social inequalities that persist in British schools (Bhopal and Rhamie, 2014). Embedding justice-oriented teaching takes time and careful consideration, further making the case for greater provision of training (particularly in-service training), which, as we argued earlier in this article, is often lacking in the educational ecosystem of England.

Furthermore, in attempting to implement the science capital teaching approach, it became clear to teachers and researchers that justice-oriented teaching cannot be enacted in a vacuum. The parallel exploration of power at societal and classroom level is crucial in the enactment of justice-oriented teaching, yet it can feel overwhelming for teachers. As pointed out by Pagán (2022), there is a need to consider larger societal barriers within which schools and teachers work to fully explore the potential of justice-oriented pedagogies. We can see these tensions coming up within our data, where teachers encounter larger issues of redistribution and inequalities within the system.

The teachers in this study were doing important work in 'straddling the line' (Debnam et al., 2023: 5) between common teaching practices and more justice-oriented teaching. Working with a teaching approach that focused on reflection and tweaking, taking the form of an extended professional development programme, meant that teachers were able to engage with the ideas over time, as they explored different aspects of the approach, providing some opportunities for what Romijn et al. (2021) call *sustainable enactment*. Limited impact studies on justice-oriented teaching similarly find that there is a need for long-term engagement for such pedagogies, rather than one-time training approaches (Bottiani et al., 2018; Brown et al., 2019).

Since this article only reports on data from teachers, we recognise that it can only provide a limited view of the impact of the approach on the students. Understanding fully the impact of the approach requires a further look at student experience of, and outcomes from, the approach. In addition, while the article focuses on pedagogies for underserved young people, it has not analysed the impact of the approach on any particular community (based on gender, ethnicity or other socio-economic backgrounds). Yet, considering that there is a lack of understanding about how in-service teachers (over time) implement justice-oriented ideas, this article makes an important contribution. It demonstrates that in-service teachers can start their journeys towards more socially just classrooms if they are provided with a framework (in this case, science capital teaching approach). More significantly, the findings show that teachers recognise the value of such efforts particularly for students from marginalised backgrounds and/or those who tend to be less likely to engage with science. The article also makes clear that the implementation of justice-oriented pedagogies must inevitably operate within a wider, unjust system that is beyond the realm of a science classroom. To counter existing inequalities in science education, justice-oriented teaching is imperative. A social justice-oriented pedagogical model built on theory and refined in partnership with teachers can (and does) positively impact the ways in which teachers interpret justice-oriented ideas, leading to positive changes to their science classrooms.

Declarations and conflicts of interest

Research ethics statement

The authors declare that research ethics approval for this article was provided by UCL ethics board.

Consent for publication statement

The authors declare that research participants' informed consent to publication of findings – including photos, videos and any personal or identifiable information – was secured prior to publication.

Conflicts of interest statement

The authors declare no conflicts of interest with this work. All efforts to sufficiently anonymise the authors during peer review of this article have been made. The authors declare no further conflicts with this article.

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