THE EQUITY COMPASS AND THE SCIENCE CAPITAL TEACHING APPROACH: TEACHER TOOLS TO SUPPORT CRITICAL PEDAGOGY

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Abstract: Science can be understood and practised in different ways. Research shows that school science often celebrates particular ways of 'doing science', and while some forms of knowledge, skills and experiences have value within a classroom, others less so. In this chapter, we begin by presenting UK-based research on science participation and discuss the challenges young people experience in engaging with science. We explain the idea of 'science capital', which has been helpful to understand the varied participation in science, drawing attention to the issues of inequalities. We then outline two practical tools that can support teachers in developing more equitable teaching practice: the Equity Compass (a reflection tool with eight equity dimensions) and the Science Capital Teaching Approach (a pedagogic approach that focuses on broadening what and who counts as science, and supporting students in making meaningful connections with science and builds science capital). We conclude the chapter by discussing how implementing the two tools can support critical pedagogy.

INEQUALITIES IN SCIENCE PARTICIPATION – INSIGHTS FROM A LONGITUDINAL STUDY OF ASPIRATIONS IN THE UK

There is ample evidence that in the UK and many other countries, there are marked patterns in who tends to study and work in science (along with wider science, technology, engineering and mathematics, or STEM, areas) (OECD, 2017; Royal Society, 2020; UNESCO, 2019). Despite decades of initiatives to encourage more diverse participation, participation in these subjects remains dominated by people from more privileged socioeconomic backgrounds. The ASPIRES study[1] (Archer et al., 2020), a longitudinal study with over 40,000 surveys in the UK tracking young people's aspirations from the age of 10 to 23, has found that contrary to a common belief, the gap in participation is not due to lack of interest or enthusiasm for science.

1. https://www.ucl.ac.uk/ioe/departments-and-centres/departments/education-practice-and-society/aspires-research

The study reports that the majority of young people found science interesting and valued science. However, they did not see themselves as 'being' or 'becoming' a scientist, or pursuing a science career. Young people's aspirations were patterned by gender, socioeconomic background and ethnicity from a young age – with high achieving, middle class, male students, and those with high levels of the family 'science capital' (see below for an explanation) being more likely to aspire to a science career and see science as being 'for me' (which is often referred to as a 'science identity').

The ASPIRES study found that young people's aspirations are shaped by a number of factors, including: i) dominant representations of science as 'clever' and 'masculine'; ii) educational practices such as science teaching, careers education and educational gatekeeping; and iii) capital-related inequalities such as what resources and support students have available. Based on the early analysis of survey data from the ASPIRES study, Archer et al. (2015) proposed the concept of 'science capital' as a way to think about capital-related inequalities that influence young people's aspirations, which we turn to next.

WHAT IS SCIENCE CAPITAL AND HOW CAN THIS CONCEPT HELP US UNDERSTAND INEQUALITIES IN SCIENCE/ STEM PARTICIPATION?

Science capital is a combination of science-related resources that a person has, including: i) what you know about science; ii) how you think (e.g., do you value science?); iii) who you know (e.g., does a family member work in science?); and iv) what you do (e.g., do you engage in science-related activities outside school, such as reading books, watching science videos, talking to other people about science?).

Research has found that young people with 'higher' science capital tend to be more likely to aspire to science and identify with science. Science capital scores vary by gender, ethnicity and socioeconomic background. In the UK, young people with 'high' science capital were significantly more likely to be boys, South Asian and from a more privileged socioeconomic background (Archer et al., 2015).

Explaining in depth the sociological theory that underpins science capital, along with the work of Pierre Bourdieu that originally proposed the concept of 'capital' and how it operates alongside 'habitus' and 'field', is beyond the scope of this chapter. But, below, we offer a short example to

illustrate how some (science) capital can be of limited value if it is not recognised, such as in the context of school science, and what this might mean for the person involved.

Alfie is 12 years old, and he aspires to becoming a DJ or a music producer. He shows little interest in continuing with education post-16 (when education is no longer compulsory). His science teacher regards him as disengaged and Alfie thinks that science is 'not his thing'. He cannot think of anyone who works in a job that uses science and says he never participates in anything science-related himself. Yet, if we think more broadly about science, we can identify a number of science-related resources in Alfie's life. For instance, Alfie's dad runs a small events company and Alfie often joins him at the weekends. Alfie is responsible for installing the music equipment and ensuring that the circuits are set up correctly and that fuses are not over-loaded. Alfie's extensive knowledge and skills, however, go unrecognised in his science lessons. He has had few opportunities to share his knowledge, skills and experience, and those of his family members (his 'science capital') at school. Consequently, he has not made a connection between his practical understanding of technical equipment and science taught at school (dictated by a curriculum). In turn, Alfie does not see his extensive science-related skills as science-related and maintains that science is not for him. (adapted from Godec, King & Archer, 2017 teacher handbook)

The above example illustrates that unless young people's science-related skills and experiences are recognised, such as within school, their value as science capital is limited. This can have implications for how young people relate to science and how much they think science is part of their lives. It is not a supposed 'lack' of science that is the problem in Alfie's case, but rather what is recognised and considered important and valuable within a specific setting (in this case, school science).

CHANGING PRACTICE: THE EQUITY COMPASS AND THE SCIENCE CAPITAL TEACHING APPROACH

In the rest of the chapter, we focus on two practical, research-based tools that teachers can adopt in their practice to reflect on how equitable their current practice is (using the first tool, the Equity Compass) and tweak their lessons to help engage more young people in equitable ways (using the second tool, the Science Capital Teaching Approach). Both tools

have originally been developed within the science education context, through extensive collaboration with informal STEM learning practitioners (the Equity Compass) and teachers (the Science Capital Teaching Approach). However, the tools are not science-specific but focus first and foremost on supporting equitable teaching and learning in a broader sense. Indeed, these tools have been applied to other contexts beyond science. For the purpose of this chapter, however, we emphasise specifically how the two tools can support science teachers.

The focus of these tools is particularly on supporting young people from minoritised[2] groups and those who have historically been excluded from science. In the context of the UK, this includes young people from lower socioeconomic background, girls – concerning *some* science/STEM subjects – and some minority ethnic groups, like Black students, who in the UK face particular disadvantages and have a low progression to science despite reporting a strong interest (Archer et al., 2020).

It is important to stress here that the tools are not aimed at simply supporting the STEM pipeline, that is, to increase and diverersify numbers of young people entering STEM careers. Rather, the tools are primarily aimed at supporting all young people to actively engage with and use a wide range of diverse science/STEM-related knowledge and skills in their lives, no matter what educational and professional trajectory they follow.

This chapter provides a brief outline of each tool, with an illustrative example for each. We provide links to more in-depth resources in the Reference section (all resources are available online in English and Portuguese).

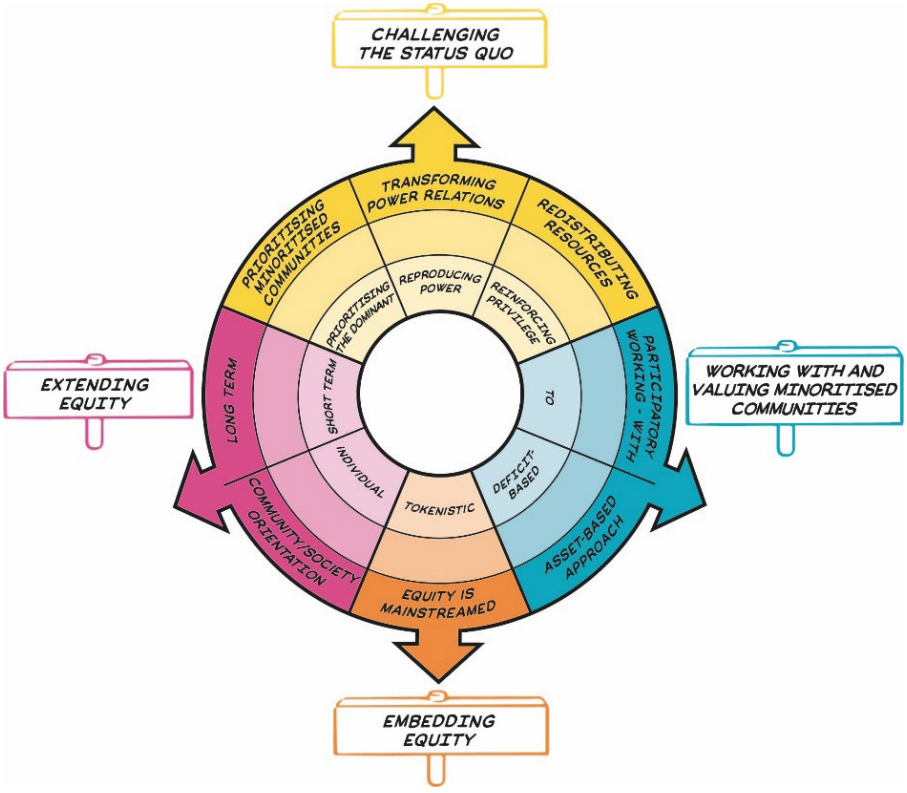
REFLECTION: THE EQUITY COMPASS

The Equity Compass (Figure 1) is a tool that can help teachers to reflect on and develop their teaching, adopting a social justice mind set (YESTEM Project Team, 2021a). The tool highlights that it is important to reflect on not just *what* you do, but *how* and *why* you do it. At the heart of the Equity Compass is a consideration of power – who drives the teaching and learning agenda, who/what is represented and who/what is excluded, and how pedagogy can be developed to best

2. We use the term 'minoritised' rather than 'minority' to put the emphasis on the systemic issues and structures that are failing to sufficiently recognise, support and value some people. People can be minoritised within a particular society depending on their race/ethnicity, gender, socioeconomic background, dis/ability, sexuality and other social axes. Who is minoritised might differ between national contexts.

support minoritised students, who less commonly have a voice and power within the mainstream education system.

FIGURE 1: THE EQUITY COMPASS



The tool was originally developed and tested in partnership with informal STEM learning settings in the UK and the US, as part of the Youth Equity and STEM (YESTEM) project[3] based in the UK at the University College London. The Equity Compass has since been used by teachers in primary and secondary schools, to date predominantly in the UK, for teaching science and other subjects, and for considering equity issues beyond the lessons.

3. https://yestem.org

Of the primary school teachers involved in the Primary Science Capital project[4], who used the Equity Compass throughout the academic year in 2020-21, 93% said that they felt that their understanding of equity-based teaching and learning had improved. Evidence from research in informal STEM learning also shows that the Equity Compass tool has supported practitioners in developing critical reflective practice, including becoming more self-reflective and intentional in their work (Archer et al., 2022).

Below, we present the four key areas of equity included in the Equity Compass: Challenging the status quo, Working with and valuing minoritised communities, Embedding equity, and Extending equity. We give examples of guiding questions for each of the eight equity dimensions in Table 1, and conclude the section with an illustrative example of how the Equity Compass has supported a teacher with reflecting on making changes in relation to one specific activity – organising a STEM career session for the students.

Four areas of the Equity Compass

Challenging the status quo is about considering the dominant relations and representations that can exclude some young people from meaningfully engaging with STEM. This equity area includes:

- transforming the dominant power relations, such as typical representations of science/STEM and of STEM professionals;
- prioritising the needs, interests and values of minoritised communities, such as ensuring the activities are guided by (minoritised) students and not the dominant players (e.g., the economy, STEM pipeline);
- redistributing resources, such as to ensure that education efforts are not further reinforcing privilege by better serving those who are already better resourced, but support those who may have traditionally had fewer opportunities.

4. https://www.ucl.ac.uk/ioe/departments-and-centres/departments/education-practice-and-society/stem-participation-social-justice-research/primary-science-capital-project

Working with and valuing minoritised communities includes:

- working 'with' students rather than delivering content 'to' or 'for' them, emphasising the importance of sharing power, and teachers and students meaningfully co-designing learning experiences together;
- taking an asset-based approach that recognises students for who they are rather than who they are not, and values their diverse knowledge, skills and experiences.

Embedding equity stresses the importance of equity needing to be mainstreamed throughout all aspects of practice and throughout the whole school and wider education system. Equity can not be limited to a few selected individuals or initiatives.

Extending equity includes:

- equitable practice being sustained and longer-term;
- ensuring that equitable practice benefits not only the students directly involved, but also for their families, their community and wider society.

The Equity Compass reflective questions

Table 1 presents examples of guiding questions for each of the eight equity dimensions covering the four overarching areas outlined above.

TABLE 1: EQUITY COMPASS GUIDING QUESTIONS (ADAPTED FROM YESTEM PROJECT TEAM, 2021A)

Equity areas	Equity dimensions	Example reflective questions for teachers
Challenging the status quo	Transforming power relations	What attention is given to understanding, challenging and transforming dominant representations of STEM (e.g., that scientists are wealthy white men)? Do students from minoritised communities feel that their classroom/school is a place where injustices in all forms (e.g., racism, sexism, ableism, classism and LGBTQI+ prejudice, and so on) are being addressed and challenged?
	Prioritising minoritised communities	Whose interests, needs and values drive your teaching and the curriculum – those of the 'dominant' groups (e.g., STEM industry, STEM pipeline – reflecting a need for more future STEM professionals) or those of students, particularly those from minoritised communities?
	Redistributing resources	How are minoritised students being supported? Are opportunities, e.g., additional activities and school trips, predominantly directed at more privileged students?
Working with and valuing minoritised communities	Participatory working – with	How participatory is your teaching? What opportunities are available to students to have any say in what and how they are being taught?
	Assets-based approach	How are you valuing minoritised students' identities, cultural, experiential and home knowledge and experiences – within and beyond STEM?
Embedding Equity	Equity is mainstreamed	How mainstreamed, intentional and foregrounded are equity issues in your teaching and at your school?
Extending Equity	Long-term	How are equity initiatives and experiences extended towards being longer term? How does the school track student experience to monitor equity issues and impact?
	Community / Society orientation	To what extent does your teaching support more collective, community-oriented outcomes (e.g., identifying systemic inequalities within the school and the community it serves)?

The Equity Compass tool is designed to be a formative tool to support honest, on-going reflection. It is not about trying to get a 'perfect score' or ticking off areas as 'done'. Developing equitable practice is an on-going process. The Equity Compass can be used to reflect on anything from an individual science lesson to a school-wide programme, and can also be helpful for strategic thinking and development. Working with school leaders in the UK, for instance, we also developed a version of the above questions specifically for school leaders and governors (YESTEM Project Team, 2021b), which would be useful for anyone in a leadership role.

An illustrative example of the Equity Compass in action

To illustrate how the Equity Compass has been used by teachers in the UK, we present a short case study, highlighting the specific equity dimensions **in bold**.

In the UK, schools often invite professionals to talk to students about their job, with the aim of enthusing students for specific careers. Here, we present a case of a Civil Engineer visiting a school on an annual basis to talk about his work at a local construction company, to inspire students to pursue STEM careers.

The engineer is an older man who usually wears his construction hat to school visits. He speaks to students about how he became an engineer, what his day looks like and how exciting it is to go into engineering. The presentation is followed by a short hands-on activity where students build bridges using lolly sticks.

The students generally enjoy the sessions and learn new things about engineering. Yet, from an equity perspective, there are aspects that could be developed further to better support all students to engage with engineering, particularly those from minoritised backgrounds who tend to be underrepresented in STEM disciplines.

Using the Equity Compass, the class teacher reflects on how the visits might be reinforcing stereotypical images of engineers (as white men in construction hats). Thinking about ways to **transform power relations**, the teacher discusses with the engineer how he could invite a discussion about the diversity challenges in the sector. The teacher also thinks about how to make the session more **participatory** and more **asset-based**, inviting a conversation about what engineering skills students have already (and valuing a broad range of skills), what students might want to know about becoming an engineer, and if and how they think engineering could help improve their lives or help a cause they care about.

The teacher also reflects on how, generally, many of the STEM engagement opportunities at their school tend to be offered to the students with the highest marks and those perceived by staff as being 'the most interested'. These students tend to be from more privileged backgrounds. The teacher decides to raise the issue at the next department meeting, with a view to developing a more inclusive approach aimed at **redistributing resources,** by ensuring that the school pays attention to supporting students from minoritised communities. One way how this could be done is by making sure that additional experiences, such as school trips and meeting STEM professionals, are open to everyone and that everyone is encouraged to attend, with support made available to those who require this.

By raising this issue with his colleagues, the teacher also made a step towards **embedding equity** at the school – working towards equity issues becoming a shared aim, while also recognising that a school has a long way to go. (Adapted from YESTEM Project Team, 2021a and 2022)

ACTION: THE SCIENCE CAPITAL TEACHING APPROACH

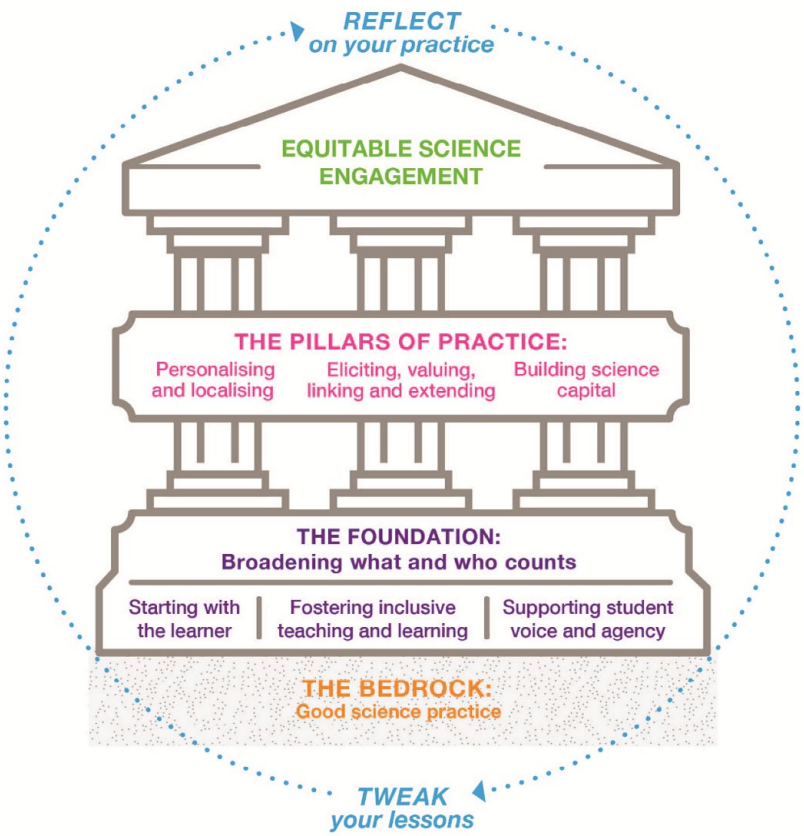
Transforming science teaching to meet social justice goals requires a critical reflection of educational practices and processes, as proposed by the use of the Equity Compass above, as well as an active shift in practice. To this second end, our research team has developed a model to support science teachers in changing their practice for equitable science engagement, by making small tweaks to their lessons while also adopting some foundational principles. While student disengagement in science in schools is a result of larger socio-political-economic factors, the approach provides specific ways in which teachers can both recognise the ways in which these impact classroom dynamics and find ways of resisting them.

The Science Capital Teaching Approach is a culmination of collaborative research and practice partnership work that started in 2013 with secondary schools (Godec, King & Archer, 2017), and since developed with primary schools in England between 2019-2021 (Nag Chowdhuri, King & Archer, 2021). The secondary school teachers involved were all science teachers. The primary school teachers, in the subsequent project, taught science as well as other subjects, which allowed us to study how the approach can work across the curriculum and inform a whole school approach to more equitable practice.

The approach is encapsulated in the model shown below (Figure 2). The approach builds on the existing good practice of science teaching and supports teachers to make tweaks based on the key

tenets of the approach. We explain the key tenets (the foundation and three pillars) below, followed by an illustrative example of what the Science Capital Teaching Approach looks like in a classroom. The approach can be used with any curriculum, any lesson plan and can support teachers to change their practice towards more equitable science teaching (and teaching other subjects, too).

FIGURE 2: THE SCIENCE CAPITAL TEACHING APPROACH



Science Capital Teaching Approach Model

Foundation of the Science Capital Teaching Approach: broadening what and who counts

At the heart of the approach is the essential foundation that is based on broadening what and who we value in science teaching and learning. The foundation encourages teachers to challenge traditional representations of science as white, male, hierarchical, elite etc., making science teaching and learning more equitable and participatory.

Thus, teachers reflect on both 'what' is being taught as school science (can we widen what sort of scientific knowledge and discourse enter the lesson?); and who gets valued as being 'good' or 'bad' in science (can we focus on who tends to be labelled as being less scientific?). This foundation supports teachers and schools to think about current practices and, thereafter, expand these practices to support a wider range of scientific behaviours and contributions.

The foundation seeks to value all students and focuses on changing the way we teach science in order to better engage all students, but particularly those from minoritised communities. In the following sections, some of the practical ways of broadening what and who counts are presented.

STARTING WITH THE CHILD

The first way to broaden what and who counts in science lessons is to 'start with the child'. This foundational activity reinforces the value of child-centred teaching and learning, and helps bring it to the forefront of teachers' thinking and planning. Teachers intuitively consider their students' needs, but the pressures of covering content can sometimes hinder child-centred teaching. Focusing on how students experience lesson content and what they might already know about the content, rather than thinking primarily about the content that has to be delivered, can make lessons more meaningful for all involved. Starting with the child also means explicitly recognising the unique contributions that each student can make to a class, and considering how you can value and address this through your teaching. This aspect of the foundation has several similarities with the idea of 'working with and valuing minoritised communities' from the Equity Compass (see above).

FOSTERING INCLUSIVE TEACHING AND LEARNING

Different students engage with science lessons in different ways and to different extents. Often, science is taught from the perspective of the most privileged, which can lead to different groups of students (from certain communities) being more likely to feel excluded from science. Teachers already consider how best to make the content relatable to their pupils but we often do this in general terms, which can reflect the identities, experiences and interests of ourselves (the teachers), or the majority group of students. By shifting our perspectives to think about a science lesson through the eyes of those students who we might currently not be reaching, we can identify more tangible ways of adapting the lesson.

SUPPORTING STUDENT VOICE AND AGENCY

The third key element supports students to have a voice in the way lessons are designed and taught. This is not only about listening to the students but enabling their voice to direct the lessons in a way that students are able to learn science that is important to them. Student agency in science involves bringing the science back into their lives and communities, as science moves beyond the classroom. This supports the idea that science is not just a destination (future science careers), but a vehicle that empowers students to be able to live in a democratic world which they can impact using their socio-scientific skills, experiences, knowledge and understanding.

Three pillars of the Science Capital Teaching Approach: techniques to build on the foundation

The three supporting pillars of the Science Capital Teaching Approach are built upon the foundation of broadening what and who counts. These three pillars provide techniques for teachers to enact the approach: personalising and localising; eliciting, valuing, linking and extending; and building science capital. An illustrative example including the elements of the foundation and the pillars is provided later in this section.

PERSONALISING AND LOCALISING

Personalising and localising is about making science content *personally relevant* to the everyday lives of students. The key is to relate the content to examples and experiences from the students' own lives. This is not just about contextualising science using general real-life examples, but engaging more deeply with students' lives to understand the knowledge, skills and experience they bring with them. These then become part of the science lessons through personalised and localised science teaching.

ELICITING, VALUING AND LINKING AND EXTENDING

Eliciting, valuing and linking and extending supports students in feeling that their ideas and experiences are valid in the context of science. It helps students feel more able to contribute and participate in the science classroom. In this way, more students feel that science can be for them.

BUILDING SCIENCE CAPITAL

To help support students' engagement with science, teachers can *build* their students' science capital by embedding the four areas of science capital (what they know, how they think, what they do, who they know) across and throughout their lessons. This pillar includes both recognising existing resources that students already have and developing new resources and experience that we know from research are important for supporting young people's identities, aspirations and participation in science (see science capital explanation above).

An illustrative example of the Science Capital Teaching Approach in action

The example below shows how one of the teachers, Mr Williams, used the Science Capital Teaching Approach in his science lessons.

Mr Williams is a Year 3 teacher (teaching students aged 7-8). He finds the social justice orientation of the approach particularly appealing as a lot of the students in his class, while being interested in science, don't always engage in the lessons. For a science lesson on 'sounds', he decided to start with the students' understanding of sound (**Foundation: Starting with the child**). Mr Williams asks the students to note down all the sounds they hear on their journey from school to home (**Pillar: Personalising and localising**, focusing on students' everyday experiences). This was an experience common among all students and did not depend on the resources or backgrounds of the students.

Mr Williams encouraged the students to share their list and made sure to recognise and appreciate all contributions (**Pillar: Eliciting, valuing, linking and extending**). He was particularly focused on those students who are less often vocal in class and who tend not to see themselves as being 'scientific'. The rest of the class listened carefully to each other, as they were also keen and intrigued by the contributions of these students who hardly spoke (**Foundation: Fostering inclusive teaching and learning**).

The classroom culture shifted slightly when it wasn't just about getting the 'right' answer but creative observations that the students had about sounds in their environment. Students swiftly moved the conversations to what they like or dislike about these sounds. The teacher supported and encouraged this discussion, and surprisingly one of the girls who would often be quiet in class talked about her experience with sound. She often had to use noise-cancelling headphones in class as she found loud sounds and a lot of students talking together irritating. She described how these sounds made her feel, which was an interesting perspective for both the teacher and her peers. Letting the students speak about their experiences and bringing that into science lessons really reshaped the dynamics within the class.

The teacher finished the lesson by asking the students whether they can think of anyone in their extended family who needs to know about sound in their work or hobby (**Pillar: Building science capital**). The students' contributions included a range of jobs and activities, within and beyond science, including a childminder (who needs to make sure the space is quiet enough for children to nap), a restaurant manager (who needs to think about the volume and sounds to accommodate guests) and a museum guide (who is often in charge of a session for children with autism and needs to make sure the environment is not overstimulating). This conversation contributed to students' understanding of transferability of science skills and help them see that many of their family use science skills in their work, even when their jobs might not be typical science jobs. (Adapted from Nag Chowdhuri, King & Archer, 2017)

CONCLUSION: HOW DO THE EQUITY COMPASS AND THE SCIENCE CAPITAL TEACHING APPROACH SUPPORT CRITICAL PEDAGOGY?

Freire (1970) said that there was no such thing as neutral education. At their core, both the Equity Compass and the Science Capital Teaching Approach are concerned with issues of power, equity and social justice. These tools acknowledge that continuing with things 'as they are' is not neutral but perpetuates inequalities. By challenging the dominant power relations and working with and valuing young people from backgrounds who have been historically excluded from STEM, we see these tools having the potential to address the relations between 'the oppressor' and 'the oppressed', to use Freire's (1970) terminology.

We would argue that the tools presented in this chapter also help challenge what Freire (1970) called the 'banking model of education', whereby learners are regarded as passive participants in their learning, expected to receive, memorise, and repeat information – while the power and authority mostly stays with the teacher. Freire wrote that "the teacher teaches and the students are taught, the teacher knows everything and students know nothing, the teacher thinks and the students are thought about, the teacher talks and the students listen… the teacher confuses the authority of knowledge with his or her own professional authority" (p. 73).

While science education literature on teaching and learning has recognised several ways of challenging this antiquated view of teaching, by embracing ideas such as inquiry-based learning and context-based learning (Sevian et al., 2018), there still seems to be a lack of focus on issues of power and privilege. For example, context-based science learning has been important to science education, but it often focuses on application, comprehension and utility of science in everyday life rather than forgrounding cultural, personal and political aspects of students and schooling (Sevian et al., 2018). This issue is also compounded as there is scant coverage of social justice theory and pedagogy within much both initial teacher education provision as well as continued professional development within the contemporary school's landscape in UK (Bagley & Beach, 2015). As a result, practices in science

lessons often continue to reproduce inequalities rather than explicitly challenge them (see Archer et al., 2017 which talks about mascular intellect being valued within science lessons).

Specifically, the Equity Compass' focus on *Working with and valuing minoritised communities* (*Participatory working* and the *Asset-based approach*) and the Science Capital Teaching Approach's focus on *Starting with the child* and *Supporting student voice and agency* are examples of how these tools offer ways to creating a shift towards the teacher no longer being the (only) one who teaches, but rather is one who works together *with* students – and learns from and with them. Further, the Science Capital Teaching Approach's *Personalising and localising* and *Eliciting, valuing, linking and extending* can support critical pedagogy-informed strategies whereby students explore issues and topics that are meaningful to their lives, while their existing knowledge, skills and experience are being recognised and valued. This focus, we would suggest, can extend to young people themselves being supported to challenging inequalities in their lives, within and beyond the school walls.

In conclusion, the Equity Compass and the Science Capital Teaching Approach are two powerful, research-based tools to help teachers reflect on and develop more equitable teaching practice. By providing achievable and manageable ideas for tweaking science lessons, such as making them more personal and meaningful to students, teachers start to understand, question and resist predominant inequitable ways of science teaching and learning. It is important to note that the issues of power and inequalities are ingrained into our society, and cannot be simply remedied by tweaks to science lessons. However, these tools can be used as a means of developing an equitable mind set and a deep professional commitment to identifying and addressing inequalities – among science teachers, the schools, and the wider society.

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