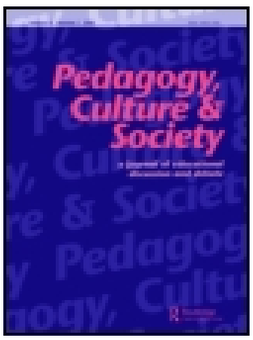

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Critical relationships between teachers and learners of school mathematics*

Pete Wright

Department of Curriculum, Pedagogy and Assessment, UCL Institute of Education, London, UK

ABSTRACT

This article draws on critical theories and perspectives on mathematics education to explain the tendency of mathematics teaching worldwide to remain focused on developing procedural understanding, despite repeated calls from the mathematics education community for a more relevant and engaging curriculum. It highlights how conventional approaches to teaching mathematics contribute towards alienating a high proportion of learners and reproducing inequities within society. The article reports on a participatory action research project, involving a group of mathematics teachers in secondary schools in England, who share a commitment for teaching mathematics for social justice. It demonstrates how, by reflecting critically on their own epistemologies and classroom practice in relation to an underlying theoretical framework, teacher researchers are able to negotiate the constraints they face in achieving this objective. Careful consideration of their relationships with students enables them to develop pedagogies that significantly heighten the engagement, and advance the empowerment, of students.

KEYWORDS

Mathematics pedagogy; critical mathematics education; equity; social justice; empowerment; participatory action research

Introduction

At the beginning of the initial teacher education course on which I am a tutor, student teachers are asked to reflect on their reasons for wanting to become mathematics teachers and the aims of mathematics education. Common responses include a desire to help students develop the numeracy, financial literacy, problem-solving skills, and deductive reasoning that they will need in their future lives. They often express hope that their students will appreciate the beauty of mathematics and how enjoyable it can be to learn. Other popular responses relate to more general educational goals, such as a wish to nurture the personal and social skills students need in order to relate to other people and lead active and fulfilling lives.

A significant number of student teachers articulate what might be described as a 'humanistic vision' in which education is viewed as integral to addressing issues relating to society as a whole. These include promoting human rights, equality, social justice, cultural diversity and sustainable development (UNESCO 2015), although it should be recognised that each of these concepts is open to a multitude of interpretations. This study focuses on how mathematics teachers might realise one such humanistic vision within their own classrooms. This vision is based on a conceptualisation of teaching mathematics for social justice that has been widely theorised in the field of mathematics education (as described

CONTACT Pete Wright pete.wright@ucl.ac.uk

* The research project that is reported in this study was carried out as part of my doctoral studies at the University of Sussex (School of Education and Social Work)

below) but rarely translated into practice. The study explores how adopting a participatory action research methodology can help teachers to overcome the numerous constraints they face in doing so. It reports on one such research project, involving a group of secondary (students aged 11–16) mathematics teachers, that was conducted as part of my doctoral studies (Wright 2015). Whilst the research was carried out across a number of schools in England, it drew on a theoretical framework informed by consideration of the wider international context.

A review of mathematics classroom practice

Unfortunately, the aspirations of new teachers described above do not reflect the reality of much current mathematics teaching in schools. Pedagogies focusing on factual recall and procedural understanding, in which mathematics is presented as a collection of 'disconnected facts and methods that pupils needed to memorise and replicate' (OFSTED 2012, 7), are all too common. Large numbers of students characterise school mathematics as being boring and irrelevant, involving the passive learning of rules with no clear purpose, limiting opportunities to work collaboratively and ignoring the needs of individuals (Nardi and Steward 2003).

Disaffection with school mathematics is not limited to students in England. Mukhopadhyay and Greer (2008, 170) describe how school mathematics in the US 'is typically considered to be boring, irrelevant, and meaningless, by adults and children alike'. Skovsmose (2011) describes an 'exercise paradigm', which dominates school mathematics classrooms worldwide, typified by the teacher demonstrating a mathematical procedure followed by learners practising the same procedure over and over again by completing a series of almost identical, closed questions. Seah and Andersson (2015) highlight how students in East Asian countries, despite their high rankings in international comparisons of performance, generally exhibit low levels of interest and enjoyment in mathematics. Askew (2015) attributes their success in school mathematics to cultural factors, including peer pressure and family honour associated with mathematical achievement, rather than to their engagement with the subject.

It is worth noting that focusing exclusively on promoting teaching approaches that are engaging and relevant might be problematic. There are a multitude of mathematical games available on the Internet that can grab and hold the attention of students, through visually appealing and life-like graphics. Unfortunately such games are typically limited to completing closed mathematical problems that are likely to cultivate dependence. These serve as a good example of how it is possible for a curriculum to be engaging and relevant, whilst at the same time disempowering.

Alienation from mathematics has been widely recognised by educational researchers who have repeatedly called for a more engaging mathematics curriculum together with a greater focus on conceptual understanding and mathematical reasoning. Skemp (1972) emphasised the importance of promoting 'relational understanding', i.e., understanding the rationale behind mathematical procedures and how to apply them to solve problems in unfamiliar contexts. Cockcroft (1982) recommended greater use of investigative tasks, whilst Boaler (1998) highlighted the advantages of open-ended, project-based approaches to learning. Swan (2006) advocated a 'collaborative orientation' in which meanings and connections in mathematics are developed through dialogue between teachers and learners, and misconceptions are used as learning opportunities. Why then, despite a 'broad international movement within the mathematics education community towards the "pedagogy of investigation"' (Gates 2006, 349), does the 'exercise paradigm' (described above) persist?

To understand the reasons why the exercise paradigm persists requires giving careful consideration to the social and political nature of mathematics education. Ernest (2004, 82) describes this field as 'a covert battleground in which the discourses of different practitioner and professional groups compete for dominance'. He argues that conflicting ideologies and views of mathematics lie behind apparent conflicts between different interest groups. He characterises most mathematics teachers and educationists as primarily concerned with the needs of the individual child and suggests they are more likely to share the kind of humanist vision described earlier. In contrast, mathematicians frequently argue for the preservation of the 'rigorous' and abstract nature of school mathematics, whilst politicians commonly focus

on the importance of mathematical skills for stimulating economic growth. Business leaders tend to promote the extension of management and accountability practices common in industry to education.

Conflicting ideologies of mathematics education became evident in the US following the publication of the 'Standards' document (NCTM 1989). Like the Cockcroft Report (1982) in England, this rejected rote learning and endorsed problem-solving approaches, discussion, reasoning and the use of calculators. During this period 'the teaching of mathematics [in the US] became the subject of heated controversies known as the math wars' (Schoenfeld 2004, 253) between 'reformers', who advocated collaborative and discovery-based modes of learning, and 'traditionalists', who sought the re-establishment of transmission-based modes of teaching and standard calculation methods (Wright 2012). Similar tensions and conflict accompanying recent educational reforms in England help to explain why many of these reforms have failed to address the real needs of mathematics learners (ACME 2011).

The growing tendency for politicians and mathematicians to involve themselves in determining educational policy has exacerbated these tensions. The promotion of a more abstract and 'rigorous' view of mathematics, through the revised mathematics curriculum in England (DFE 2013), exemplifies the negative effect ideological conflict can have on the needs of learners. The new primary (students aged 5–11) programmes of study gave much less prominence to probability and data handling with their renewed emphasis on fluency in arithmetic. The use of calculators was discouraged until the end of the primary phase and standard methods of long multiplication and division were reinstated. In the foreword to a report (Oates 2010) that paved the way for the new curriculum, Michael Gove (then Secretary of State for Education in the Coalition government) stressed the importance of 'identifying the crucial concepts and ideas that each year group should learn'. He derided the previous mathematics programmes of study (QCA 2007), introduced by a Labour government, as offering 'vague generic statements of little value'. Entire sections were deleted, including 'key concepts' (encompassing critical understanding, developing arguments and effective communication), 'key processes' (including skills required to solve complex problems and to carry out statistical projects) and 'curriculum opportunities' (such as engagement with open tasks, collaborative working and out-of-school contexts). The revised curriculum (DFE 2013) instead placed much greater emphasis on 'subject content'. Oates (2010) argued strongly that, rather than stipulating how mathematics should be taught, pedagogical decisions should be left to the professional discretion of teachers. This is somewhat disingenuous given the substantial pressures and constraints experienced by mathematics teachers as detailed below.

Through the 'academisation' programme, championed since 2000 by successive Labour, Coalition and Conservative UK governments, business leaders and corporate sponsors have played a much greater role in the administration of schools. Rising levels of marketization and competition accompanying this and other recent educational reforms have resulted in higher levels of monitoring and scrutiny of teachers, increasingly high-stakes mathematics assessments and greater pressure to 'teach to the tests' (ACME 2011; Ball 2013). Foster (2013, 569) argues that 'the backwash effects of high-stakes assessments and a systemic de-professionalisation of teachers through a performative accountability culture' has led to 'the prevalence of pedagogical reductionism', in which mathematics is broken down into bite-size chunks of knowledge that are taught sequentially, without making clear how they connect together.

I have drawn attention to contradictions that exist between teachers' motivations and aspirations at the start of their careers and common practice in schools. Gates (2006) describes how teachers' social and cultural upbringing moulds their pedagogical beliefs. This can lead to them exhibiting 'oppositional ideologies', such as a humanistic vision of education or a collaborative orientation towards mathematics teaching, that can come into conflict with the 'dominant ideologies' they encounter. Mathematics teachers show a tendency to adopt the same pedagogies they themselves experienced as learners, subconsciously crediting these for their own success, resulting in a general acquiescence to the dominant ideologies.

This review of current practice highlights the significant challenges faced by mathematics teachers wishing to realise a humanistic vision of education within their classrooms. Achieving this objective requires a deeper understanding of the constraints faced by teachers and their underlying causes. Developing strategies that might support teachers in overcoming such constraints demands a closer examination of the power relations that exist within mathematics education, and in particular, between teachers and learners in the classroom.

Critical perspectives on mathematics teaching and learning

A critical mathematics education involves paying close attention to power relationships that exist within the field of mathematics education and exploring ways of addressing these so that learning mathematics becomes an empowering, rather than a disempowering, experience. Strong correlations persist between family income and students' achievement in mathematics examinations and participation in post-compulsory mathematics studies (Noyes 2009; Boaler, Altendorff, and Kent 2011). School mathematics continues to act as a 'critical filter', with those attaining higher grades acquiring much greater access to higher status post-compulsory education courses and better-paid employment (Black, Mendick, and Solomon 2009). These two phenomena combine to ensure that school mathematics plays a significant role in perpetuating inequities that exist within society.

Bourdieu's theory of 'reproduction' regards one of the primary functions of schooling as maintaining the existing social order from one generation to the next, including inequitable power relations prevailing between different groups (Bourdieu and Passeron 1990). It does so by concealing these power relations, for example by attributing academic success to 'giftedness'. This implies that those who succeed do so because of their innate ability, rather than any systemic advantage they may be afforded. This is particularly evident in the field of mathematics education, for example it is common for teachers, students and parents to perceive mathematical ability as fixed, rather than incremental. Such views are associated with the increasing prevalence of 'setting', i.e., grouping students according to their levels of prior attainment. Wilkinson and Penney (2014) highlight how students are often assigned to such groups on the basis of their behaviour, rather than their ability, with limited opportunities for future mobility between groups. Those placed in lower sets are placed at a significant disadvantage, especially as they are more likely to experience a 'largely remedial (and boring) curriculum' (Hodgen and Marks 2009, 31).

Bourdieu uses the notion of 'cultural capital' to describe those social and cultural resources that are recognised and valued by schools (Jorgensen, Gates, and Roper 2014). He argues that children from middle-class families arrive at school already endowed with greater levels of cultural capital, acquired through their upbringing, that enable them to take advantage of the opportunities on offer (Noyes 2008). Teachers, many of whom come from middle-class backgrounds themselves, tend to hold lower expectations of children from working-class backgrounds, who they perceive as being less able to conform to expected norms of behaviour (Lerman and Zevenbergen 2004). Bourdieu argues that disadvantaged students are complicit in their own exploitation, for example by attributing their own failure to personal deficits and choosing not to study mathematics beyond the compulsory stage (Mendick 2003). He refers to this process as 'symbolic violence' (Jorgensen, Gates, and Roper 2014).

Bourdieu's analysis helps to explain why students' mathematical attainment and social class remain strongly correlated. It also supports the argument that the under-achievement of children from disadvantaged backgrounds should be attributed to systemic causes rather than to 'individual deficiencies on the part of particular pupils or parents' (Jorgensen, Gates, and Roper 2014, 225). However, it might appear somewhat fatalistic to teachers committed to the principle of teaching mathematics for social justice, as it provides an explanation for the way things are without necessarily offering a way forward. Bourdieu and Passeron (1990, 12) pose the following paradox for teachers wishing to convince students that they are not contributing to the cycle of social reproduction through their teaching:

> … either you believe I'm not lying when I tell you education is violence and my teaching is legitimate, so you can't believe me; or you believe I'm lying and my teaching is legitimate, so you still can't believe what I say when I tell you it is violence.

Bernstein's (2000) theory of 'pedagogic discourse' offers more hope to those wishing to challenge the existing power relations within mathematics education. It builds on Bourdieu's theory of social reproduction by arguing that schools create a 'mythological discourse' that attributes failure to inherent cognitive, affective and cultural deficits amongst students. However, it differs from Bourdieu's theory in that it views this process as intentional, rather than an inevitable function of schooling: 'Some social groups are aware that schooling is not neutral, that it presupposes familial power both material and

discursive, and that such groups use this knowledge to improve their children's pedagogic progress' (Bernstein 2000, xxiii).

Bernstein (2000) describes mathematics as a subject with strong 'classification', i.e., it is considered separate from other subject areas with its own specialised rules for communication and behaviour. This might explain why some students, who are comfortable working collaboratively in other subjects, find it difficult to do so in mathematics. He also argues that mathematics involves strong 'framing', i.e., the teacher is viewed as transmitting knowledge and exerting substantial control over the discursive and social order. This echoes Swan's (2006) critique of the 'transmission orientation' of mathematics teaching and learning, in which teachers explain a pre-defined set of standard procedures and provide practice exercises to check for and correct misunderstandings.

Bernstein (2000) argues that, in such a strongly classified and framed environment, students' academic success in mathematics depends on their ability to decipher the 'rules of the game'. These include 'recognition rules', i.e., identifying relevant meaning from the tasks set by the teacher, and 'realisation rules', i.e., formulating appropriate responses and legitimate actions. He contends that children from middle-class backgrounds are more likely to acquire these recognition and realisation rules through their upbringing. Cooper and Dunne (2000) highlight how, in contrast, children from working-class backgrounds commonly experience confusion when responding to 'realistic' tasks in mathematics lessons, which are often based on contrived situations bearing little resemblance to real life contexts.

Bernstein (2000) outlines how the realisation rules are less explicit in situations in which framing is weaker, such as when tackling more open-ended tasks. This can further disadvantage students from working-class backgrounds who are less able to create their own framing to make effective use of realisation rules. This poses something of a dilemma for those who advocate investigative approaches to teaching mathematics, in which learners are given less direction and greater autonomy, and who wish to achieve equitable outcomes. Lubianski (cited in Lerman and Zevenbergen 2004) highlights how working-class students in the US were disadvantaged by a model of teaching mathematics that made use of inquiry-based approaches and more relevant and meaningful contexts. Rather than using this as evidence to support transmission-oriented modes of teaching, Lerman and Zevenbergen (2004, 37) contend that 'some work needs to be done, both theoretically and practically, to mitigate the effects of invisible pedagogies – such as through modifying the strength of framing'. They argue that teachers need to reflect carefully on their own expectations of students from different social backgrounds and become more aware of how students' backgrounds influence their responses to classroom tasks. This will help them to avoid interpreting misrecognition of implicit classroom norms as non-compliant misbehaviour.

I argue therefore that the adoption of more collaborative and problem-solving mathematics pedagogies should be accompanied by approaches in which the 'rules of the game' are made more visible to students. Teachers and students should be encouraged to engage with, and reflect upon, the implicit power relationships that exist within the classroom that contribute towards reproducing social inequities. This requires teachers to develop relationships with students, based on trust and mutual respect, which enable honest and open discussions to take place. Such relationships should be based on 'personal control', where classroom rules are negotiated and their rationale made clear, rather than 'positional control', where the teacher relies on their position of authority to exert control over students (Bernstein 2000).

Outline of the research project

The research project aimed to explore how secondary school mathematics teachers, with a commitment towards a humanistic vision of education, can go about translating theories into classroom practice. The 'critical research model' of participatory action research (Skovsmose and Borba 2004) was adopted as this methodology was considered to resonate with the aims of the project in generating relevant knowledge and seeking positive social change (Brydon-Miller and Maguire 2009). Participatory action research views research as a collaborative endeavour between teachers and academics, with the former

recognised as partners in the research process rather than being considered merely as research 'objects'. It is also emancipatory in nature as it encourages teachers to develop a deeper understanding of their own situation and the constraints they face, enabling them to transform their practice in a direction they are comfortable with (Atweh 2004).

A research group was established comprising myself and five teacher researchers from four different schools. All five had accepted invitations I sent out to those nearing the end of their first year as newly qualified teachers who had previously completed an initial teacher education course on which I was a tutor. Over the course of one academic year, the research group collaborated in planning, trying out, and evaluating a series of classroom activities and teaching ideas.

The research can be considered participatory in that teacher researchers contributed agenda items to the research group meetings and discussions at the meetings determined the direction in which the project developed. Teacher researchers were asked to read and present relevant research literature to the rest of the group. They designed the activities to be tried out in their classrooms, agreed data collection tools for recording students' responses, and maintained their own reflective journals. Data were generated from the teacher researchers' evaluations of classroom activities and reflections on their own practice. Initial findings from the data analysis were presented back to teacher researchers for validation and further discussion.

My role was largely facilitative and included drawing attention to relevant research literature, organising and chairing research group meetings, circulating summaries of discussions and decisions taken, analysing the data and reporting the findings of the study. However, my role also included that of critical partner, encouraging teacher researchers to interrogate prior assumptions and current practice in relation to theory. Kemmis (2009, 471) argues that for action research to be considered 'critical', those involved should aim to 'change their social world collectively, by thinking about it differently, acting differently, and relating to one another differently'. Jaworski (2006) highlights how external support and stimulus is vital in developing critical understanding and challenging the status quo. The 'critical research model' (Skovsmose and Borba 2004) is based on the fundamental assumption that the 'current situation' should not be taken as given, and that, through developing a critical understanding of this situation, alternative possibilities should be explored.

A framework for teaching mathematics for social justice was adopted at the start of the research project. This framework draws on the critical perspectives on mathematics teaching and learning discussed earlier, and in particular on two influential authors in this field: Gustein and Skovsmose. Gutstein (2006) builds on Freire's ideas on critical education, arguing that students should engage in 'reading and writing the world with mathematics'. This involves using mathematics to develop a better understanding of issues relating to power, including inequity and discrimination, and how these affect students' own lives and society as a whole. Skovsmose (2011) argues that critical mathematics education should include students reflecting 'through' mathematics (by participating in meaningful inquiries in which they take their own decisions), reflecting 'with' mathematics (by developing a deeper understanding of various social, political, economic and cultural situations) and reflecting 'on' mathematics (by considering the nature of the subject and how it affects society).

The framework for teaching mathematics for social justice included the following five components:

(1) Employ collaborative, discursive, problem-solving and problem-posing pedagogies which promote the engagement of learners with mathematics;
(2) recognise and draw upon learners' real-life experiences in order to emphasise the cultural relevance of mathematics;
(3) promote mathematical inquiries that enable learners to develop greater understanding of their social, cultural, political and economic situations;
(4) facilitate mathematical investigations that develop learners' agency, enabling them to take part in social action and realise their foregrounds and
(5) develop a critical understanding of the nature of mathematics and its position and status within education and society (Wright 2015, 27).

Seven meetings of the research group were held over the course of one year. During the first meeting, I presented the above framework, and its underlying theories, to the group. Teacher researchers then related these to their own classroom practice. Subsequent meetings of the research group, spanning three participatory action research cycles, included the planning, teaching and evaluation of classroom activities. Teacher researchers presented their evaluations to the rest of the research group, prompting further discussion and critical reflection on theory and practice.

Data were collected through audio recording the research group meetings and a series of three semi-structured interviews that I conducted with each teacher researcher, at the start, mid-way through, and at the end of the research project. Interview questions focused on the development of thinking and classroom practice in relation to the aims of the project. I adopted an 'empathetic' approach towards interviewing, based on the principle that establishing trust between interviewer and interviewee enables meaningful representations of interviewees' views to emerge (Fontana and Frey 2008). The audio recordings were transcribed and a thematic analysis was carried out on the transcripts. This involved breaking the text down into 'units of meaning' (Kvale and Brinkmann 2009), which were then summarised and assigned categories based on inductive coding, i.e., the categories were decided after an initial reading of the data. These categories were then used to compare commonalities, differences and relationships between units of meaning, allowing themes to emerge from the data (Gibson and Brown 2009).

The thematic analysis was an iterative process in which initial themes were related back to the underlying theories to give further meaning to the data and allow new analytical questions to emerge (Jackson and Mazzei 2012). In order to ensure the 'trustworthiness' of the research, careful consideration was given to the credibility, dependability, confirmability and transferability of the findings (Lincoln and Guba 2003). Various research methods were employed for this purpose, including the use of 'member checks' (Shenton 2004), which involved presenting initial findings back to the teacher researchers for their comment.

Findings from the research

Four overarching themes emerged from the data analysis and these were used as the basis for subsequent analysis, as well as providing a useful structure for reporting the findings. One of these themes related to the collaborative nature of the research group, with teacher researchers reporting how much they valued the opportunity to work together with colleagues from different schools and to engage with theory and research literature. They also appreciated the mutual support provided by the research group, which helped them to try out ideas and overcome many of the constraints they faced in developing their practice. This theme is explored in more detail in other articles that focus on the methodological aspects of the research project. I concentrate here on the other three themes, which I consider to be particularly relevant to the pedagogical focus of this study.

I present below extracts from the stories of three of the teacher researchers, Anna, Brian and Rebecca (all pseudonyms), which were selected in order to illustrate these themes. All three taught mathematics in ethnically diverse comprehensive schools in Inner London that had relatively high proportions of students with statements of special educational needs, who spoke English as an additional language, and who were eligible for free school meals. More detailed accounts of individual teacher researchers' experiences, the development of the research group and the role played by the critical research model are reported in my doctoral thesis (Wright 2015).

Theme 1: changing epistemologies of mathematics

The first theme that emerged was the apparent change in epistemologies of the teacher researchers over the course of the research project. There was considerable discussion during research group meetings around teachers' views of mathematics, students' perceptions of the subject, and how these influenced the pedagogical approaches teachers adopted. The teacher researchers' thinking around classroom

practice, in particular their views on whether focusing on issues of social justice in the mathematics classroom was legitimate, were closely linked to their developing relationships with the subject.

Anna chose to study mathematics at Advanced Level (students aged 16–18) after recognising its importance as a gatekeeper qualification. Her strong interest in humanities led her to study psychology at university and to develop an interest in social justice issues. It wasn't until she trained as a teacher that she began to consider questions about the nature of mathematics:

> I always remember this session we did where they were saying 'What is maths?' And I was like 'What is maths? I've just joined this teacher training course to teach maths and I don't really know what it is'. (Anna, Interview 2)

Brian was already interested in social justice issues before becoming a teacher and this was reflected in his previous involvement with a global poverty charity. He studied for a geography degree, but decided to teach mathematics because he recognised the gatekeeper role it played. He was motivated by a desire to address injustices and inequality in society and initially viewed helping disadvantaged children attain higher grades in mathematics as a palpable way of achieving this. He also felt strongly that teachers should help students develop into 'confident, resilient, hopefully joyful individuals' (Brian, Interview 1).

Rebecca had been happy to study mathematics for its own sake and was attracted by what she saw as its abstract and precise nature. She studied mathematics at degree level and claimed that she wouldn't have felt comfortable teaching any other subject. She only began to appreciate the need to make mathematics relevant to students after becoming a teacher. She described how perplexed she and her department had been when asked by school managers to incorporate spiritual, moral, social and cultural aspects of learning into the mathematics scheme of work and was intrigued by my invitation to participate in the research project:

> When I saw your first email, first of all I had to google it because I didn't have a clue what you were going on about. But it's just never occurred to me to try and teach maths in that sort of way. I'd never heard of teaching maths for social justice before. (Rebecca, Meeting 1)

Through her involvement with the research project, Rebecca developed a much greater awareness of her own and other people's perspectives on mathematics. She began to question her previous assumptions about its value-free nature, and described making a conscious effort to link mathematics to the real world for the sake of her students. Similarly, Anna showed a growing appreciation of the socially-constructed nature of mathematics. She began to argue that teachers should not avoid engaging with political aspects of mathematics, since students were exposed to numerous negative messages about the subject elsewhere.

Brian described becoming more aware of differing perspectives on mathematics education, including the obsession of politicians with how it contributes towards economic growth. He contrasted his own focus on developing mathematical skills useful in future life with that of influential mathematicians, who emphasised the importance of rigorous deduction and proofs. He developed an increasingly critical perspective on mathematics education, beginning to appreciate how schools perpetuate injustices. He began to advocate the importance of students developing critical understanding, for example, through appreciating how to think independently and develop their own arguments. He also argued that school mathematics had a vital role to play in countering myths students were exposed to regularly in the media.

Anna initially saw social justice issues as an opportunity to enrich mathematical learning and was concerned about the amount of 'concrete' mathematics that would be learnt. She focused at first on using mathematics as a means of raising awareness of social issues such as wealth distribution. She later began to appreciate how mathematics learning and social justice were inextricably linked, recognising how applying mathematical ideas to meaningful contexts contributed towards deeper understanding and longer-term retention of mathematical concepts. She noted how students grasped the link between percentages and a hundred-square more easily when exploring how the money paid for a Fairtrade chocolate bar was distributed and how this might be represented. She recognised the value of providing real life contexts that were convincing and genuine, rather than over-simplistic and contrived.

Rebecca began to recognise how using real life contexts helped students to identify patterns and to generalise, rather than merely manipulate numbers without appreciating their meaning. She described how generating a discussion around differences between male and female earnings encouraged students to focus on the mathematical properties of a dual bar chart. She became increasingly confident in using social justice issues to enrich her mathematics lessons, replacing what she considered to be the pseudo-realistic contexts she had used previously. She began to focus on broader learning objectives such as how to develop a mathematical argument.

Anna argued that students, from an early age, should be oriented towards an alternative view of mathematics in which procedures are routinely applied to realistic contexts through extended projects. This would require careful planning to ensure students were challenged to apply mathematical skills beyond those in which they were already proficient:

> And the kids are going to have to be coming to me and saying 'Oh we've got these numbers but how do we represent this?' And it's their questions that are going to be the need for them to learn the stuff, as opposed to me saying 'this is something we're learning, go away and do it'. That's the dream. (Anna, Interview 2)

Brian became increasingly convinced of the need to connect mathematical skills to social justice issues. The more he incorporated social justice issues into his mathematics lessons, for example by using global inequality to explore cumulative frequency, the more students began to see these as a normal and legitimate element of their mathematics learning. He described how students began to adopt a broader view of mathematics, appreciating its application to real life and questioning its purpose less often.

Theme 2: developing student agency

The second theme to emerge was the growing interest amongst teacher researchers in student agency, which became a focus for the development of their practice. The research project reinforced their belief that school mathematics should be more engaging, relevant and meaningful, and they began to appreciate how promoting the mathematical agency of their students was one way of achieving this.

Brian strengthened his belief that adopting collaborative, discursive and problem-solving approaches would make mathematics more fun and lead to more equitable learning outcomes:

> I think things such as trying to give them a bit of agency and choice in lessons, things like encouraging them to work together in groups … have been things that I've done more of because, as part of the project, I've found them to be helpful and useful. (Brian, Interview 3)

Rebecca was pleased with the extent to which her students engaged with issues of equality and fairness that she introduced to her lessons, particularly those who normally lacked confidence in mathematics. She enjoyed teaching these lessons more as a result. Anna also reported how students responded very positively to the activities, exhibiting much higher levels of engagement and motivation, which made the lessons more enjoyable and satisfying to teach. She described a lively debate amongst students around the amount of tax and profit received by the government and supermarkets from the sale of Fairtrade chocolate bars. She found that the improvement in engagement was greatest amongst lower-attaining students:

> I tried a few things with my bottom set and their motivation has just been so high in those particular lessons that I've had to very rarely like tell them to get on with things or to do things. (Anna, Interview 3)

Brian reported how the enthusiasm with which students embraced discussions enabled them to develop considerable insight into social justice issues. For example, after exploring how different voting systems can lead to different outcomes in an election, students began to question who would choose which system to use. Improvements in attitudes towards mathematics were most noticeable amongst those students who previously participated less and behaved worse in mathematics lessons.

Rebecca described how the research literature she encountered during the research project reinforced her belief that students require mathematical understanding to make sense of the growing amount of information in the world, and to avoid being exploited by others:

> Unless you actually have some kind of understanding of how to look at statistics, and how to look at the information that's given, and when to question it, and, you know, 'What's reliable and what isn't?' then you don't have a hope. (Rebecca, Interview 1)

Rebecca outlined her initial frustrations with the 'Making a Change Project', an activity she devised herself, in which students were encouraged to choose an issue, research it, identify something they would like to change about it and then develop a mathematical argument to support their case. On reflection, she concluded that she began by providing too little structure, resulting in students seeking unrealistic changes such as amendments to the school rules on body-piercing. When she tried the activity for a second time, she provided more guidance, for example on how to argue for a change that might be achievable, whilst still allowing students to choose their own issue. This time she felt that students made more realistic suggestions for change and used mathematics more effectively in supporting their arguments. Developing student agency, which she acknowledged was not something she had considered before the research project, became central to the development of her thinking.

The Making a Change Project (described in Wright 2016) was embraced enthusiastically by the other teacher researchers. Anna was particularly pleased with the willingness students showed in constructing and presenting their own arguments for change, when given the opportunity to choose and explore topics of interest to them:

> They were all so passionate about the things they were presenting about, was the key thing, and the fact that they got to actually tell everyone what they found out. (Anna, Interview 3)

She did however feel that students needed more support in developing the skills required in order to make good use of mathematics in presenting a powerful argument. Brian felt his strategy of asking students to compare pairs of mathematical and non-mathematical statements, such as 'one in five people go to bed hungry each night' and 'there are lots of people in the world who are hungry', went some way towards achieving this.

Brian was impressed by his students' willingness to change their opinions after listening to each other's arguments, for example when they used statistical data to justify how to allocate scarce water resources in a hypothetical scenario. However, there were other occasions when he was frustrated by students' apparent reluctance to reconsider stereotypical views, for example when examining real data that contradicted tabloid headlines such as 'immigrants swamping the country'. Rebecca was also disappointed by views expressed by students after scrutinising the proportion of income from Fairtrade chocolate bars received by the cocoa producers. A heated discussion about how little they were paid (4% for Fairtrade compared to 0.5% for non-Fairtrade) led to most students claiming they would not buy Fairtrade in future. She believed students had missed the point that producers earn eight times as much from a Fairtrade chocolate bar.

Brian described how the research project had enabled him to develop much closer relationships with his students. Encouraging students to talk openly about their feelings towards mathematics, and about the issues they faced in their everyday lives, gave him a greater appreciation of the 'raw deal' they received from conventional mathematics teaching. He claimed that enhanced levels of trust made it easier to convince students to engage with teaching approaches he considered more beneficial to them. Anna also reported how the research project encouraged her to talk to students about their real life situations, and to establish stronger relationships with students based on mutual trust. This had a positive impact on learning across all mathematics lessons. She noted the need to deal with some issues sensitively, such as unemployment, which might directly affect a number of students in the class.

Theme 3: dominant discourses on ability and attainment

The third theme to emerge was around dominant discourses. Anna, Brian and Rebecca began to reflect upon, and seriously question, their own notions of mathematical ability and the desirability of setting students in groups of similar prior attainment. They began to recognise systemic factors that limited the

mathematical attainment of some students, and to relate these to constraints they faced in developing ideas around teaching mathematics for social justice.

At the start of the project, a common belief amongst teacher researchers was that the most effective strategy for addressing issues of inequity in mathematics education was to focus on raising the attainment of disadvantaged students:

> I've chosen to teach in a school where it's classed as a challenging school, because the kids stereotypically wouldn't be expected to achieve very much. … So I think, in the sense of bringing about social justice through education, I'm involved in that just through being at this school. … I'm still very much passionate about my pupils getting grades, because they need these grades, more than other kids need grades, because they're going to be fighting against kids who've been to grammar schools, who have parents who can pay for them to have internships, all these different things. (Anna, Interview 1)

Anna, Brian and Rebecca became increasingly confident that incorporating social justice issues in teaching was not in conflict with raising mathematical attainment. Anna reported how making mathematics more relevant and meaningful for students led to longer-term gains in mathematical understanding.

Anna and Brian identified how close monitoring and scrutiny by managers discouraged teachers from adopting innovative teaching approaches, because of a perceived need to provide immediate evidence of short-term progress made by students:

> I think it makes you less likely to take risks with your classes. If you know that there's a chance that someone pops in, you're more likely to do lots of very average lessons, than one lesson that could blow up in your face or it could go amazingly, because you know that you'd be judged on that one lesson. (Brian, Interview 1)

Brian highlighted how evaluations of students' progress were often based on simplistic measures, such as the volume of written work, rather than on qualitative improvements in attitude towards mathematics or awareness of social justice issues. In contrast however, Rebecca highlighted how rigorous monitoring and scrutiny existed in her school alongside an expectation that lessons would be interactive and engaging, thus encouraging creative teaching approaches.

Brian reported how pressure to get through the scheme of work, in preparation for periodic high-stakes tests, also acted as a constraint. He described successfully navigating this constraint by linking social justice issues more closely to mathematical topics. Rebecca felt a similar compulsion to cover the subject content and was frustrated by the limited time available for students to learn how to apply mathematics procedures to unfamiliar contexts:

> I do think I feel under more pressure to get through all the material. I am struggling a bit on that front, which means that any social justice activity has to be very specifically linked to something, a mathematical skill that is not going to be taught in any other way. (Rebecca, Interview 2)

Anna believed strongly that adopting collaborative and problem-solving approaches to learning was especially important for students placed in lower sets, who were more likely to lack confidence and self-esteem. However, she acknowledged that these students might need more support in engaging with such pedagogies. Brian argued that students in lower sets had the most to gain from the research project because they were more likely to be disadvantaged in their future lives by lack of success in mathematics. He described how these students generally struggled to engage with open-ended activities, resulting in a tendency for them to be given shorter and more closed tasks. Teachers often perceived them as being less motivated and disposed towards learning, and consequently adopted approaches that limited their opportunities for developing critical and independent thinking. He noticed that the same students found it difficult to appreciate issues of 'fairness' and struggled to manage their own behaviour and relationships with other students. This led him to stress the importance of cultivating a degree of compliance with social norms, as well as developing critical thinking amongst students. He highlighted how some students might need more help and encouragement to develop the personal and social skills required to become successful learners of mathematics.

Rebecca highlighted how her students' behaviour was a significant constraint on the teaching approaches she adopted. With more challenging students she tended to adopt a structured approach in which there was less opportunity for students to reason mathematically or work on open-ended tasks.

She tried out most ideas from the research project with one class, with whom she had established more positive relationships and trust over a longer period of time, and who were therefore more inclined to accept different approaches.

Brian noticed that the increases in engagement with mathematics that he observed were more modest amongst higher-attaining students. He attributed this to the satisfaction such students felt from answering questions correctly, which others got wrong, and how they might perceive alternative teaching approaches as potentially undermining their success:

> I think, if you are at the top end of the top set, you've put your hat on the fact that you get things right, and as soon as in maths it's no longer about you getting the right numerical answer, you suddenly feel like things are not under your control any more, and you're not top dog any more. (Brian, Interview 2)

Anna began to seriously question the practice of setting students into groups according to prior attainment, arguing that this tended to concentrate together those with poor behaviour and less positive attitudes towards mathematics. She argued that students with weaker communication skills would benefit from engaging in discussions with more articulate students. She showed increasing interest in schools that achieved high grades whilst teaching in mixed-attainment groups and expressed a desire to introduce such grouping herself should she become a head of department. Brian also grew increasingly critical of setting, blaming it for the widening gap in mathematical attainment during secondary schooling. He believed mixed-attainment groups would help promote richer discussions across all mathematics classrooms. However, he recognised that teachers' common perception of mathematics as being centred on procedures and calculations reinforced the belief that narrowing the range of attainment in mathematics classes would make teaching simpler. He became frustrated that, despite his best efforts, students continued to exhibit a belief that success in mathematics was down to innate ability rather than effort.

Discussion

It was noticeable how Anna, Brian and Rebecca, whilst sharing a humanist vision of education, had given little thought to the nature of mathematics before the research project. In my experience this is not uncommon amongst beginning mathematics teachers. Ernest (2004) suggests a strong association between a 'fallibilist' view of mathematics, which involves recognising its socially-constructed and value-laden nature, and a humanist vision of mathematics education. The significant changes in epistemologies of mathematics experienced by the teacher researchers suggest that this association is best explained by a greater disposition amongst those mathematics teachers embracing a humanist vision to reflect on their views of mathematics. Doing so appears to enable them to align their mathematical epistemologies more closely with their underlying ideologies of education.

In becoming more aware of their own epistemologies and perspectives on mathematics education, all three teacher researchers reinforced their commitment towards adopting more student-centred, collaborative, discursive, problem-solving teaching approaches. Bourdieu argues that teachers' 'habitus' inhibits them from questioning a system within which they have experienced success themselves, leading them to adopt the same pedagogies they encountered as learners (Bourdieu and Passeron 1990). This suggests that encouraging teachers to reflect critically on their own epistemologies and ideologies, as was the case for the teacher researchers in the project, is essential for advancing the alternative teaching approaches described above. Gutstein (2006) asserts that such pedagogies are a necessary, but not sufficient, condition for teaching mathematics for social justice.

The research project demonstrated how teacher researchers were able to transform their thinking and classroom practice, moving away from regarding social justice merely as a way of enriching mathematics lessons, towards recognising it as a legitimate and essential aspect of mathematics learning. It illustrates how, by making school mathematics more relevant and meaningful, and enhancing the links between social justice issues and mathematical skills, teachers can help students to develop deeper and longer-term mathematical understanding. This echoes Freire's (1974) contention that genuine

understanding can only be developed through enabling learners to become conscious of their own situation and how this relates to their learning. A significant increase in engagement and motivation towards learning mathematics was reported by the teacher researchers, particularly amongst students who had previously exhibited low confidence, poor behaviour and negative attitudes towards the subject. This suggests that the framework for teaching mathematics for social justice employed in this project offers a useful starting point for teachers wishing to address the high levels of alienation currently experienced by many learners of mathematics (Nardi and Steward 2003).

Anna, Brian and Rebecca displayed growing interest in developing student agency and their experiences of the Making a Change Project illustrate how this remains a challenging, and often neglected, area of pedagogical development for teachers. Gutstein (2006) argues that students need to be actively engaged in social action, for example by campaigning on the issues they are exploring with mathematics, in order to develop agency. However, this is not always feasible in a classroom setting. The research project demonstrated how teacher researchers enabled their students to take decisions regarding their own learning, to make use of mathematics to better understand an issue of their choice and strengthen their arguments for a change they would like to see made. This offers a pragmatic approach to promoting students' agency that prepares them to engage in social action in their future lives.

The research project poses an interesting dilemma regarding the extent to which students should be encouraged to adopt 'desirable' (from the teacher's perspective) attitudes towards social justice issues. The example of students claiming that they would no longer buy Fairtrade products, after discovering how little money goes to the producers, appears at first sight to conflict with the goal of a humanist vision of education. However, this viewpoint could also indicate a more critical understanding, i.e., that Fairtrade products involve inequitable power relationships in their production, albeit slightly less unfair than conventional trade.[1] Freire (1974) would argue that, from a 'radical' perspective, the teacher's role is to promote debate and reflection on an issue, working with learners to develop a 'critical awareness' and arrive at a solution. This is preferable to teachers imposing their own views, which Freire would describe as a 'sectarian' approach. This provides a challenge to traditional relationships between teachers and students, which are based on the assumption that knowledge is merely transmitted from one person to another.

The research project highlighted how challenging dominant discourses on ability and attainment is essential for establishing a socially-just pedagogy. It underlines the importance of building positive relationships between teachers and students, based on mutual trust, before adopting innovative teaching and learning approaches that might be perceived as high risk by both groups. Grootenboer (2013) argues that teachers and researchers should pay closer attention to such relationships, particularly in mathematics lessons, where students often exhibit higher levels of anxiety. Sensitivity towards students' feelings and emotions towards mathematics is vital in helping them all to succeed. Establishing an open and supportive classroom environment was seen by teacher researchers as a necessary precondition for students to develop the personal and social skills they require to become successful learners of mathematics and to reflect on their personal situations.

Providing additional support to disadvantaged students, to help compensate for their lack of 'cultural capital', must however be balanced with their need to acquire critical understanding and independent learning skills. This resonates with Bernstein's (2000) contention that working-class students may be further disadvantaged by the adoption of less structured teaching approaches unless the 'rules of the game' are made clear and transparent. Teacher researchers recognised the need to challenge their own tendency to provide excessive structure and direction to lower-attaining students, who are more likely to lack confidence and exhibit poor behaviour. Such awareness is a pre-requisite for disrupting the cycle of 'symbolic violence' (Bourdieu and Passeron 1990) in which some students, by conforming to expectations that they cannot engage with alternative pedagogies, are complicit in receiving a restricted curriculum offer.

The commitment of all three teacher researchers towards equity and social justice manifested itself initially through a focus on attaining the highest possible mathematics grades for students from disadvantaged backgrounds, reflecting the 'social mobility' discourse common in schools. Bourdieu and

Passeron (1990) warn that examples of children, or schools, in deprived areas that manage to buck the trend, and attain high mathematics grades against the odds, merely give legitimacy to the myth that mathematics education is based on a meritocracy. This contributes towards disguising its primary purpose of reproducing social inequities.

The research project demonstrated how teacher researchers, by reflecting critically on their practice in relation to theory, developed a greater appreciation of structural problems and systemic failures that contribute towards reproducing inequities. An example is the prevalence of setting students into groups of similar levels according to prior attainment. This practice was increasingly blamed by teacher researchers for widening the achievement gap between higher-attaining and lower-attaining students. Critical reflection increases awareness of the constraints teachers face in developing their practice, for example the pressure to cover subject content. It facilitates the development of strategies for overcoming these constraints, such as establishing clearer links between social justice issues and mathematical content. Straehler-Pohl and Pais (2014, 81) argue that mathematics education research must address the constraints faced by practitioners and recognise that 'the production of failure is a structural problem' if the goals of advancing equity and inclusion are to be realised.

Conclusion

Conventional approaches to teaching mathematics continue to alienate students and limit opportunities for developing the kind of mathematical understanding required to solve complex problems in unfamiliar contexts. Underlying this practice are power relations and ideological conflicts that ensure school mathematics persists in ignoring demands from teachers and educationists for a more engaging curriculum, and continues to contribute towards the reproduction of social inequities. Given this situation, it is hard to envisage government-led policy changes that will lead to positive social change in the field of mathematics education.

This research project demonstrates how school teachers, holding a humanistic vision of education, can initiate changes in their classroom practice that both engage and empower mathematics learners. It highlights how such changes do not conflict with their desire to raise the mathematical attainment of disadvantaged students. It shows how mathematics teachers, with a commitment to equity and social justice, can become more comfortable in their roles as practitioners.

In order for teachers to transform their practice, careful consideration needs to be given to negotiating the numerous constraints that stand in their way. Teachers need to critically reflect on their own mathematical epistemologies and current practice, in relation to underlying theoretical frameworks, so that they can develop pedagogies that are genuinely empowering, rather than exploitative. They need to identify clearly the links that exist between social justice issues and mathematical content so that they are not criticised for failing to cover the scheme of work. They need to convince senior managers of the need to focus on students' attitudes towards learning, and deeper and longer-term mathematical understanding, when monitoring the progress made by students.

In order for mathematics learning to become genuinely empowering, teachers need to reflect carefully on the relationships they build with students. The research project highlights how trust needs to be established between teachers and students to enable the adoption and development of alternative pedagogies. Relationships also need to be transparent, with teachers helping students to reflect on their views of mathematics and to make sense of their own learning situations. The challenge is to enable all students, particularly those from disadvantaged backgrounds, to develop the types of behaviour, social skills and dispositions that they need to become successful learners of mathematics.

Note

1. Note that the reaction of students subsequently led to a redesign of the activity from a more critical perspective, e.g., its title was changed to 'How fair is Fairtrade?' (Wright 2016).

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ORCID

Pete Wright http://orcid.org/0000-0002-6926-4237

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