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Social justice in the mathematics classroom

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Despite increases in educational attainment in London, too many mathematics lessons remain focused on factual recall and procedural understanding, resulting in disaffection among learners. This study reports on the establishment of a research group, comprising five teacher researchers and myself, which aimed to challenge this situation through adopting a participatory action research methodology. By planning, teaching, and evaluating innovative classroom activities, the group demonstrated how making mathematics more relevant and meaningful can enhance students' engagement and agency. The collaborative and mutually supportive nature of the group developed teacher researchers' self-efficacy in addressing issues of social justice in their mathematics classrooms.

Keywords: social justice; mathematics; participatory action research

Introduction

You could be forgiven a degree of complacency towards the current state of mathematics education in England given apparent increases in attainment over the past 20 years. The percentage of candidates achieving top grades (A* to C) in mathematics in the General Certificate of Secondary Education (GCSE) examination, taken at the end of compulsory schooling at age 16, has risen steadily from 45 per cent in 1995 to 63 per cent in 2015. Children in London schools outperform others across England. The above measure of mathematics performance is currently 2 per cent higher in London, which has also seen a significantly higher rate of improvement in GCSE performance in recent years than elsewhere (GLA, 2014).

Yet these figures contrast with growing evidence, some of which is presented in the next section, suggesting unacceptably high levels of alienation and disengagement from mathematics among a large proportion of learners. They also hide worrying differences in achievement between different groups of learners that highlight persistent inequities in mathematics education.

This paper argues that the current situation that predominates in mathematics classrooms, described below, should not be taken as given, and that alternative approaches towards teaching mathematics should be adopted that address issues of equity, fairness, and social justice. It reports on a research project involving a group of secondary mathematics teachers in London schools, committed to the principles of teaching mathematics for social justice, who set out to put some of these ideas into practice. It recounts the experiences of the teacher researchers and discusses how the development of their thinking and classroom practice has implications for others involved in mathematics education.

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What's wrong with mathematics education?

By the age of 16, children in England will typically have spent approximately 2,000 hours learning mathematics in school. Yet very few will have considered questions such as 'What is mathematics?' and 'Why do we spend so much time learning it?', suggesting a general acceptance of its position in our society. Mathematics plays an important role as a 'critical filter', providing greater access to further education and higher-paid employment for those who are successful (Black *et al.*, 2009; Wolf, 2002). However, not everyone agrees that this status is fully warranted and some question the extent to which mathematics qualifications provide skills that are useful to employers.

Lerman (2000: 21) attributes the privileged position mathematics occupies in the curriculum to the status the subject has been afforded 'as an exemplar of truth and rationality since ancient times'. Success in mathematics is often used as a measure of general intelligence, a damaging misperception that is associated with a view of mathematical ability as fixed rather than incremental (D'Ambrosio, 2008). Notions of fixed mathematical ability underlie the predominance of setting in England, where students considered to be 'higher ability' are taught in separate groups and provided with a more demanding curriculum than those considered to be 'lower ability' (Morgan, 2009). Despite a lack of evidence that setting is effective (Winbourne, 2009), the vast majority of students in England aged 12 or older are taught mathematics in ability groups, with many in lower sets receiving a largely uninspiring curriculum and considering themselves as failures from an early age (Hodgen and Marks, 2009; Brown, 1999).

Successive UK governments, driven by international comparisons of performance, have given increasing priority to raising attainment in mathematics. Mathematics assessment in England has become increasingly high-stakes, with GCSE mathematics given particular importance in a new measure of performance for schools. Together with accountability measures introduced in the 1990s, this has been blamed for an increasing tendency to 'teach to the tests', with a greater focus on factual recall and procedural understanding. This is at the expense of skills that are more difficult to assess (i.e. problem solving, reasoning, and communication), which are precisely those demanded by higher education and employers (ACME, 2011).

Nardi and Steward (2003) describe the 'quiet disaffection' of large numbers of learners who characterize school mathematics as being boring, irrelevant, passive, ignoring individual needs, and teaching rules without any rationale. Even successful learners become alienated from mathematics through fear of identifying themselves as passive receivers of knowledge (Boaler and Green, 2000). It is not surprising that it becomes socially acceptable to admit to disliking or being bad at mathematics, given the disengaging way the subject is commonly taught and the perceived failure experienced by so many students (NCETM, 2008).

The figures for GCSE mathematics attainment also hide worryingly high levels of inequality in achievement and participation among students from different groups. Girls continue to display significantly lower participation rates in post-compulsory mathematics education, despite their GCSE attainment being similar to boys, and there remains a strong correlation between achievement in school mathematics and social class (Boaler *et al.*, 2011; Noyes, 2009). Given the role school mathematics plays as a 'critical filter', these differences in achievement and participation inevitably lead to the perpetuation of social inequities.

Evidence suggests that teaching mathematics through more open-ended, collaborative, problem-solving approaches, with students in mixed-attainment groups, leads to more equitable outcomes and promotes greater participation among both boys and girls in post-compulsory mathematics education (Boaler, 2008). So why do conventional approaches to teaching mathematics persist despite the priority afforded by governments towards mathematics education over the past 30 years? Over the same period, consensus has grown among the mathematics education community that a more relevant and engaging mathematics curriculum

is needed, with greater emphasis on conceptual understanding and problem solving (Cockcroft, 1982; ACME, 2011; Ofsted, 2012).

Bourdieu (1998) argues that one of the primary functions of schooling is to reproduce the current social order and to maintain unequal power relations existing in society. It does this by concealing these relations, for example, by falsely attributing academic success to notions of giftedness or merit, which is evident in the prevalence of setting in mathematics classrooms. Schools claim that they offer equality of opportunity – whereas, in reality, some students possess higher levels of the 'cultural capital' that is recognized and valued by schools (Jorgensen *et al.*, 2014). Bourdieu argues that, through their upbringing, children from middle-class families acquire higher levels of cultural capital than those from working-class families, placing them at an advantage before they arrive at school (Noyes, 2008).

I outline in a previous paper (Wright, 2012) how successive UK governments have increasingly intervened in the development of the school curriculum. This has led to a greater influence on school mathematics of educational ideologies that champion the abstract and rigorous nature of the subject, and promote practices common in business and industry, including selection and marketization. This helps to explain why, despite government rhetoric calling for a new generation of creative and mathematically proficient problem-solvers able to drive forward economic growth, most students continue to experience mathematics lessons that involve completing a series of almost identical, closed questions.

Skovsmose (2011: 9) describes this as the 'exercise paradigm', which cultivates a 'prescription readiness' and 'prepares the students for participating in work processes where a careful following of step by step instructions without any question is essential'. Gutstein (2006: 10) argues that such a disempowering mathematics education for the majority reflects capitalist economies' need for 'an ever-growing army of low-skilled, compliant, docile, pleasant, obedient service workers'. As well as helping to understand and explain the current situation described above, such critical perspectives offer an alternative vision of what mathematics education might look like in practice.

Teaching mathematics for social justice

This study develops a conceptualization of 'teaching mathematics for social justice', which provides a challenge to the status quo, described above, that disengages and disempowers mathematics learners. It draws on Freire's notion of 'critical education', which advocates the emancipation of learners and the development of critical citizenship (Skovsmose, 2011). It is based on the premise that mathematics education can and should play a role in addressing difficulties faced by our society, including growing inequality, human rights abuses, and unsustainable economic growth (Cotton, 2013).

Skovsmose (2011) argues that a critical mathematics education should include reflecting 'through', 'with', and 'on' mathematics. Learners should reflect 'through' mathematics by engaging in meaningful mathematical inquiries in which they pose their own questions and make their own decisions, while interacting and communicating with others. They should reflect 'with' mathematics by using it as a means to develop their understanding of a range of social, cultural, economic, and political issues. They should reflect 'on' mathematics by considering its nature and privileged position, and appreciating how it can be used to make and justify decisions affecting their lives.

Gutstein (2006) outlines how adopting a curriculum which emphasizes reasoning, problem solving, and communication, in order to develop 'mathematical power' or the confidence to engage in complex mathematical tasks, is a necessary – but not sufficient – condition for the

empowerment of learners. He goes further, drawing on Freire's notion of 'praxis', to argue that students should use mathematics to investigate and challenge injustices and inequities relating to their own lives and wider society. He emphasizes that 'reading and writing the world with mathematics' depends upon students being willing to rethink their views of mathematics, teachers appreciating the socio-political nature of mathematics, and developing meaningful relationships between students and teachers.

The following conceptualization of teaching mathematics for social justice (Wright, 2015: 27), drawing on the ideas of Skovsmose and Gutstein described above, is adopted for this study:

- employ collaborative, discursive, problem-solving, and problem-posing pedagogies, which promote the engagement of learners with mathematics
- recognize and draw upon learners' real-life experiences in order to emphasize the cultural relevance of mathematics
- promote mathematical inquiries that enable learners to develop greater understanding of their social, cultural, political, and economic situations
- facilitate mathematical investigations that develop learners' agency, enabling them to take part in social action and realize their foregrounds
- develop a critical understanding of the nature of mathematics and its position and status within education and society.

The research project

In May 2013, I contacted 120 mathematics teachers who were nearing the end of their first year as qualified teachers, and who I had previously worked with as a tutor during their initial teacher education programme. I invited them to take part in a research project, which aimed to develop ideas and classroom practice that challenged the status quo, and which addressed issues of social justice in the mathematics classroom. The invitation included details of the conceptualization of teaching mathematics for social justice, which was to serve as a useful starting point, and the 'critical research model' (see below), which was to be adopted for the project. Participants were self-selected on the basis of sharing a commitment to the aims of the project and a willingness to make the necessary time commitments. These included attending seven twilight meetings, carrying out at least three classroom interventions over one academic year, participating in three interviews – at the start, midway through, and at the end of the project – maintaining a research journal, and completing a short report at the end of the project.

The Teaching Mathematics for Social Justice Research Group was established in June 2013. It comprised five teacher researchers and me (as university-based researcher). The research group was collaborative and participatory in nature. While I played an important role in facilitating the meetings of the group, and collecting and analysing research data, the teacher researchers took much of the initiative for developing their own practice. They chose which teaching ideas to develop, led the evaluation and discussion of activities they tried out in the classroom, and decided the method for collecting feedback from students (through a written survey administered immediately after the activity).

The design of the research project was based on the 'critical research model' of participatory action research (Skovsmose and Borba, 2004). This model assumes that the 'current situation' – in this case, the typical experience of mathematics learners in classrooms – should not be taken as given. It stresses the importance of an alternative vision or 'imagined situation' – in this instance, the initial conceptualization of teaching mathematics for social justice described earlier. It proposes the use of an 'arranged situation', whereby the participants in the research,

taking into account the constraints of the current situation, put into practice some aspects of the imagined situation. The three key processes of the critical research model (i.e. 'pedagogical imagination', 'practical organization', and 'explorative reasoning') were integral to the operation of the research group.

Pedagogical imagination involves developing a critical understanding of the current situation; for example, by gaining insight into how critical perspectives (Gutstein, 2006; Skovsmose, 2011) might help to explain this situation. Teacher researchers were encouraged to engage with research findings and discuss how these related to their own experiences and represented viable alternatives to current practice. The first meeting of the research group focused on theoretical ideas underlying the research project; for example, I asked the teacher researchers to read and discuss a short introductory chapter from a book focusing on rethinking school mathematics from a social justice perspective (Gutstein and Peterson, 2005).

Practical organization involves cooperation between research participants in organizing an arranged situation. The second, fourth, and sixth meetings of the research group focused primarily on jointly planning activities to try out in the classroom. Teacher researchers were encouraged to present ideas taken from currently existing resources (Wright, 2004; Gutstein and Peterson, 2005), discussing how they might incorporate these into their lessons, bearing in mind the constraints of the classroom.

Explorative reasoning involves analysing the arranged situation in order to better understand the current situation and the feasibility of the imagined situation. The third, fifth, and seventh meetings of the research group focused primarily on evaluating and reflecting on the activities tried out in the classroom. Teacher researchers took it in turns to present their evaluations, making use of student feedback, examples of students' work, and notes from their research journals to inform their presentations. Presentations were followed by questions from other teacher researchers and a general discussion, which informed subsequent planning, teaching, and evaluation cycles.

Data collection and analysis

Semi-structured interviews were conducted by me, in the teacher researchers' own schools, using an 'empathetic' approach, in which a relationship of trust is established and a story is constructed jointly through interaction and dialogue between interviewer and interviewee (Fontana and Frey, 2008; Kvale and Brinkmann, 2009). Initial questions focused on the development of interviewees' thinking and classroom practice relating to social justice. Individually tailored follow-up questions were used to explore responses in more detail and to stimulate further discussion. Audio recordings of all research group meetings and individual interviews were transcribed using a literary style (i.e. ignoring pauses, fillers, and voice intonations).

A thematic approach was used to analyse the transcripts using 'meaning condensation', in which the text is broken down into units of meaning and summarized, and 'meaning interpretation', involving assigning a category to each unit of meaning (Kvale and Brinkmann, 2009). The analysis drew on methods from grounded theory, which I considered to be consistent with my critical research methodology. While maintaining that current practice should not be taken as given, and offering an initial conceptualization for a more desirable alternative, there was no pre-existing hypothesis on how this conceptualization should be translated into classroom practice. Thus it was possible for theories and hypotheses to emerge within a theoretical framework that informed and guided the action research cycles.

This thematic analysis made use of inductive coding, whereby the categories assigned to each unit of meaning were derived from initial readings of the data. Categories were then used

to facilitate the comparison of commonalities, differences, and relationships between units of meaning, enabling new themes to emerge (Gibson and Brown, 2009). Such comparisons, in contrast to simplistic coding that is more easily quantified, take into account the context of the text, allowing meaning to be constructed from the stories of the research participants. Initial findings from the data analysis were then related back to the theories underlying the project in order to generate new analytical questions giving further meaning to the data (Jackson and Mazzei, 2012).

Careful consideration was given to Lincoln and Guba's (2003) framework for ensuring the trustworthiness of qualitative research, with particular attention paid to the credibility, transferability, dependability, and confirmability of the research findings.

The 'credibility' and 'confirmability' of the findings – that is, confidence that the phenomena are accurately represented and derived from the experiences of the participants – were promoted through adopting various procedures focusing on reflexivity and triangulation. These included: maintaining my own research journal and code log; 'prolonged engagement' with teacher researchers over a period of one year; the use of student surveys and final reports to triangulate data; 'iterative questioning' through following up previous responses in individual interviews; and 'member checks' through presenting my analysis back to teacher researchers for their comment (Shenton, 2004). A second thematic analysis was carried out on a selection of the data in order to assess the credibility of the research processes. This analysis made use of deductive coding, based on the key processes of the critical research model, and previously established reliability criteria for action research – that is, the extent to which it is participatory, collaborative, relevant, and results in positive social change (Brydon-Miller *et al.*, 2003).

The 'transferability' and 'dependability' of the research (i.e. enabling the reader to make an informed judgement about the relevance of the findings to his or her own situation, and to repeat the study if desired) were assured by providing 'thick descriptions' of the context of the research and its design (Shenton, 2004). These include detailed descriptions of the research model and framework for analysing data, my own background and the development of my interest in the field, and a detailed case study of the research group and the teacher researchers' involvement in the project. These descriptions, while too lengthy to include in this paper, can be accessed through my doctoral thesis (Wright, 2015).

Research findings

Four themes emerged during the analysis of the first set of interviews and these were used as the basis for the thematic analysis of data from subsequent meetings and interviews. The four themes provided a useful structure for reporting the findings of the research project, using a case study approach to narrate the stories of the teacher researchers' involvement in the project and the development of their thinking and practice. The five teacher researchers – Anna, Brian, George, Rebecca, and Sarah (all pseudonyms) – taught in multi-ethnic comprehensive schools in Inner London with varying records of attainment in GCSE examinations. Their schools all shared a relatively high proportion of students who spoke English as an additional language, students with statements of special educational needs, and students eligible for free school meals.

Theme 1: Changing epistemologies of mathematics

The development of the teacher researchers' classroom practice over the course of the project appeared to be closely related to their changing views of mathematics and their students' perceptions of the subject. While they all considered themselves to be successful learners of

mathematics, they viewed the subject as entirely content-focused when they themselves were at school, only later beginning to appreciate its value-laden and socially constructed nature. The most significant changes in their epistemologies of mathematics took place during their initial teacher education programme, and through their involvement with the project:

> 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)

Through reflecting on the nature of mathematics during research group meetings, they became more aware of their own perspectives and how these affected their approaches to teaching.

By engaging with research theories and trying out ideas in the classroom, the teacher researchers began to rethink their ideas about addressing issues of social justice. There was a distinct move away from viewing these ideas merely as a way of enriching lessons towards seeing them as a legitimate and essential aspect of teaching mathematics, which promoted mathematical understanding and made the subject more relevant and meaningful to students:

> It's given me the confidence to step off the scheme of work treadmill, of getting through different topics or chapters, and actually saying: 'Well, these topics, say cumulative frequency, or percentages, I can fit these within a project on something to do with these kids' world, or to do with our world as a whole.'
>
> (Brian, Interview 3)

Over the course of the project, the teacher researchers became more and more critical of conventional mathematics teaching, increasingly seeing this as resulting in procedural understanding and causing students to view mathematics as boring and pointless. At the same time, they strengthened their belief in student-led, collaborative, discursive, problem-solving approaches to learning:

> 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)

However, they continued to recognize the importance of learning discrete mathematical skills, which they believed should be complemented by, rather than replaced by, tackling issues of social justice. There was a growing appreciation of the need to establish stronger links between social justice issues and mathematical skills at an appropriate level of challenge for students. While incorporating social justice issues began to impact on students' perceptions of mathematics, the teacher researchers reported that some students, particularly where they found the mathematical content too easy, expressed concern that they were not studying 'real' or 'proper' mathematics.

Theme 2: Developing student agency

Three of the teacher researchers cited a desire to change society for the better as a reason for becoming a mathematics teacher in the first place. All five shared a strong belief in tackling inequity through raising the attainment of disadvantaged students, which explains their choice of an initial teacher education programme that placed them in schools with relatively high levels of socioeconomic deprivation. They viewed motivating students as a high priority and convincing students of the utility of mathematical procedures, by making the subject more realistic and meaningful, was seen as a way of achieving this.

> The maths today made me realize how the simplest maths can change lives.
>
> (Year 10 student in Brian's class in response to activity on Fairtrade)

The teacher researchers initially felt most comfortable developing activities that involved using mathematics to develop a better understanding of social justice issues, including public misperceptions about benefit fraud and immigration, the sustainable use of water and allocation of resources, average incomes and global inequality, voting systems, and Fairtrade. They reported a genuine interest for such issues among students, together with a developing appreciation of how mathematics might be used to solve problems in real life.

Over the course of the project, there was growing interest among the teacher researchers in developing student agency, something they had given less thought to previously.

> I think the agency thing was definitely something I hadn't considered at the start. Like, I saw it more as applying maths to different situations, rather than using maths to actually change something.
>
> (Rebecca, Interview 3)

The 'Making a Change' project, which involved students using mathematics to develop their understanding of an issue of their choice and present an argument for a change they would like to see made, became the focus of the third action research cycle. While fostering students' mathematical engagement and agency became increasingly important to the teacher researchers in the development of their practice, there was a growing appreciation that the notion of 'student agency' needed to be handled carefully. George warned that agency, on its own, was not necessarily desirable as students also needed to develop open-mindedness and sensitivity towards issues of social justice in order to become positive agents of change. The question of whether teachers should encourage students to explore issues and arrive at their own conclusions, or guide students towards developing particular beliefs and values, was highlighted during the Fairtrade activity when some students openly questioned the validity of Fairtrade.

> I think maths today was good as it's showing actual statistics which has made me think 'fair trade' isn't fair.
>
> (Year 9 student in Rebecca's class in response to Fairtrade activity)

The teacher researchers reported that most students responded positively to the activities, demonstrating greater levels of engagement and enjoyment of learning through their behaviour and responses to the feedback survey. This was particularly noticeable among students who had previously been poorly motivated and badly behaved in mathematics lessons:

> 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)

Theme 3: Collaborative nature of research group

The teacher researchers described how the opportunity to work collaboratively with colleagues from different schools in a research group attracted them to the project. The invitation came towards the end of their first year as qualified teachers, after which they would no longer be receiving the same level of structured support and professional development from their schools. They were just beginning to think about the direction they would like their practice to develop, and where they might get support to help them achieve this.

> I think the whole project is, for me, about developing myself as a practitioner, and in a way that I'd like to develop.
>
> (Anna, Interview 1)

The group quickly established positive working relationships, helped by the fact that they knew each other from their initial teacher education programme. The mutually supportive nature of the group encouraged the teacher researchers to take risks and overcome many of the challenges and constraints they encountered in developing alternative classroom practices:

> And it's also provided that additional incentive to do it, and to take the risk, because you know that you're going to be asked to talk about it. But also you know you're going to be allowed to talk about it in a way that says that messing up doesn't matter.
>
> (Brian, Interview 3)

This was exemplified by the way in which the rest of the group encouraged and reassured Rebecca after she presented the evaluation of her initial attempt at the Making a Change project. Having been the first in the group to try the activity, she was clearly disheartened by the logistical problems she encountered. However, the rest of the group recognized the potential of her ideas and went on to develop them into a successful activity.

> It is quite useful having that kind of, I don't know, support almost, and being able to just tell someone exactly what happened and have their, kind of, outside view on it.
>
> (Rebecca, Interview 2)

The teacher researchers were keen to engage with the research theories underlying the project, and reported how these challenged their preconceptions, enabling them to develop a broader and deeper understanding. They acknowledged the role I played, as university-based researcher, in raising their awareness of these theories and providing a structure for developing ideas. They concurred that engaging with theories, discussing ideas, and comparing experiences – along with the collaborative planning, teaching, and evaluation of classroom activities over a sustained period – had a considerable impact on their thinking and practice:

> It's been the most impactful CPD, in my opinion, that I've had this year, because it's sustained … I've actually seen the impact of this project on the children and the lessons that I teach, whereas very often with CPD, it's one afternoon, you go away and come back, and it goes out of your head like that.
>
> (Anna, Interview 3)

The teacher researchers' growing confidence in translating research theories into classroom practice was evident in the way they began to encourage other teachers in their school to take on board the ideas from the project. Anna, Brian, and Rebecca ran related training sessions for their departments, and three of the schools used activities from the project with an entire year group. It became apparent that news of the positive impact the activities had on students spread quickly and generated interest in the project across departments.

> Success has bred more success, because if they've seen a lesson go well, then they want to teach it, and then their lesson goes well, and then it sort of spreads.
>
> (Rebecca, Interview 3)

Theme 4: Dominant discourses on ability and attainment

The teacher researchers became increasingly aware of constraints that they felt might discourage teachers from promoting social justice in the mathematics classrooms – in particular, the exam-focused culture in schools, excessive workload, and high levels of scrutiny of teachers. There was growing appreciation that a narrow focus on raising the attainment of disadvantaged students, while ignoring structural inequities, resulted in low-risk teaching and procedural understanding:

> 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)

The teacher researchers concurred that the mutual support provided by the research group helped them to overcome many of these constraints. Developing a greater understanding of the links between social justice issues and mathematical skills enabled them to resolve the conflict between tackling these issues and getting through the scheme of work. Sharing ideas and resources within the group compensated for the additional time required to plan meaningful activities. The positive impact of the project, on students' engagement and mathematical understanding, reassured the teacher researchers that the project's aims were not in conflict with the desire to raise mathematical attainment:

> 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)

The teacher researchers reported an initial tendency to try out new ideas with higher-attaining students, who were generally better behaved and more positively disposed towards learning. However, over the course of the project, they began to realize that the benefits were most apparent for lower-attaining students, who demonstrated greater improvements in their levels of engagement and achievement. It became noticeable that the highest attaining students showed the least enthusiasm towards alternative teaching approaches advocated by the project, perhaps because they associated their own relative success with conventional teaching approaches:

> 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)

Over the course of the project, the teacher researchers began to question previously held assumptions about mathematics teaching, particularly the notion of mathematical ability being fixed. Initially, there was little criticism of the rigid setting prevalent in their departments. However, they began to question its benefits, expressing increasing concern that concentrating together students with lower confidence and less positive dispositions towards learning might contribute towards widening differences in attainment.

Implications of the research project

The research project, with its methodology based upon the critical research model and the initial conceptualization of teaching mathematics for social justice, was focused as much on the process for bringing about change as on what that change might look like. This focus is reflected in the research findings, which have implications in three areas: mathematics teaching, the professional development of mathematics teachers, and mathematics education research.

Implications for mathematics teaching

The project demonstrated how mathematics can serve as a powerful means for developing students' understanding of issues of social justice, and that students are likely to develop an

understanding of both social justice issues and mathematical concepts when there is a meaningful link between the two. It showed how student agency can be developed by adopting collaborative, problem-solving approaches to teaching, and encouraging students to choose which issues to explore and which mathematical procedures to apply. Developing and presenting their own arguments enables students to gain an appreciation of how mathematics can be used to better understand a situation and to argue for a change.

The project highlighted how making mathematics more meaningful and relevant to students' real-life experiences can raise their levels of engagement with the subject as they develop an appreciation of its purpose and possible future application. This is particularly noticeable among lower-attaining and previously disaffected students, suggesting that such an approach has the potential for closing the attainment gap among students – although the duration of the project was too short to provide any evidence of this happening. However, care needs to be exercised when relating mathematics to students' real-life experiences. Educational opportunities for disadvantaged students can be restricted if connections are made only with their backgrounds. For this reason, Skovsmose (2011) argues that mathematics should relate to students' 'foregrounds' – that is, real-life experiences that move beyond their current situations. While there may be some resistance to these teaching approaches among higher-attaining students, it should be noted that many such students choose not to study the subject beyond the compulsory level. Initial resistance might therefore be outweighed by the potential of these approaches to encourage more students to study mathematics at higher levels.

The project also demonstrated how engaging with research findings enables teachers to develop insight into structural inequities in mathematics education. Through developing an appreciation of the processes that lead some students to become alienated from mathematics, teachers may become more willing to use a range of alternative pedagogies with students who are less predisposed towards, but have the most to gain from, discursive, open-ended approaches to learning.

Another issue highlighted by the project was how uncommon it is for students, even those studying mathematics at degree level, to be asked to reflect on the nature of the subject despite the privileged position it occupies in the school curriculum. Encouraging students to do so appears to be an effective way of challenging myths, such as the belief that mathematics is value-free or that mathematical success is pre-determined by innate ability, perhaps preventing these myths from being perpetuated from one generation to the next. Enabling students to better understand their own situation can help those who are disadvantaged in learning mathematics to overcome barriers to achieving success. Furthermore, the project emphasized the importance of establishing relationships based on trust and mutual respect between teacher and students if such discussions are to have any effect.

Implications for the professional development of mathematics teachers

The project demonstrated how the critical research model, with its focus on relating theory to practice and ensuring that the current situation is not taken as given, can have a considerable impact on the thinking and classroom practice of mathematics teachers with a concern for social justice. The role of the external partner – in facilitating the engagement of such teachers with research findings, and encouraging them to critically appraise their own practice in relation to theory – was shown to be a crucial aspect of the model. This process allows teachers to develop a more profound and critical understanding of their own practice and how this relates to existing practice across different schools. It can lead to greater awareness of structural causes of inequity and injustice in mathematics education, including the use of setting to group students by attainment and ignoring the effect of social class on students' achievement.

Addressing issues of equity and social justice was shown to be an important factor for some mathematics teachers in deciding to become a teacher in the first place. The project suggested that such teachers are favourably disposed towards reflecting on their epistemologies and experiences as learners. In so doing, they are likely to strengthen their belief in the effectiveness of student-led, collaborative, problem-solving approaches to learning. The critical research model allows these teachers to re-engage with ideas, which they may have lost sight of as a result of pressures they face in the classroom, enabling them to become more comfortable in their roles as mathematics teachers. The high level of interest in the project shown by the teacher researchers' colleagues indicated that there might be significant numbers of mathematics teachers in schools sharing a concern for social justice issues.

The project highlighted the effectiveness of a collaborative, participatory, and sustained approach to professional development. Collaborative relationships that develop over a prolonged period of time enable teachers to provide the mutual support necessary to overcome constraints and to take risks in the classroom. Through the joint planning of lessons and the sharing of experiences among colleagues from a range of different schools, teachers are able to engage with new ideas and develop their thinking appreciably. The critical research model demonstrates how teachers are able to develop their agency and self-efficacy in deciding the direction and extent of changes in their classroom practice.

Implications for mathematics education research

The project demonstrated how the critical research model can enable teachers, through reflecting on classroom practice and its underlying theories, to generate relevant knowledge that is transferable to other classroom situations. The project showed how research undertaken collaboratively with teachers working in 'typical' classroom situations (i.e. those where common issues and constraints relating to developing practice are present) is likely to be perceived as relevant and authentic by other teachers. Such research therefore has the potential to increase teachers' engagement with research findings.

The critical aspect of the research design enables new knowledge to be generated that challenges existing discourses in schools, and has the potential to address inequities and injustices existing within mathematics classrooms, schools, and wider society. The project outlined processes that enable transformations in classroom practice to take place, and highlighted how university-based researchers and teacher researchers can act collaboratively as agents of change.

Research based on collaborative and participatory methodologies is generally under-represented in academic journals, reflecting a lack of confidence in its reliability. Through the attention paid to issues of trustworthiness, only some of which is presented in this paper, the project demonstrated how participatory action research from a critical perspective can be systematic and rigorous, as well as generating relevant knowledge with the potential to bring about positive social change.

Conclusion

The research project reported in this paper provides some insight into what teaching mathematics for social justice might look like in practice, and how it can be promoted through an effective model of professional development. It also demonstrates how teachers and researchers can work collaboratively, through systematic inquiry, which generates reliable and trustworthy findings, to challenge the current situation in which mathematics teaching perpetuates inequities and injustices within society. It is unlikely that those in positions of power will embrace the findings of this research, since their interests might be better served by maintaining the status

quo. However, it is hoped that those committed to education as a means of changing the world for the better might gain some insight from the project's findings into how to go about bringing about positive change in the mathematics classroom.

Notes on the contributor

Before joining the UCL Institute of Education as a Lecturer in Mathematics Education in 2011, Pete taught for 15 years in comprehensive schools in London, Newcastle-upon-Tyne, and Brighton, including three years as Head of Mathematics, and in a rural school in Kenya. Other posts in education include five years in curriculum development and two years as a local authority mathematics consultant. His current research interests include equity and social justice in mathematics teaching and participatory action research.

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