Primary Maths and Social Justice Research Project (PMSJ)

Report (January 2023)

Lead researchers:

- Dr Pete Wright (Senior Lecturer, University of Dundee)
- Dr Caroline Hilton (Lecturer, UCL Institute of Education)
- Mr Joel Kelly (Assistant Headteacher, The Blue School)

Teacher researchers (all pseudonyms):

- David (Year 2), Emma (Year 1), Kate (Year 1), Layla (Year 6) – from East Primary School
- Aidan (Year 2), Rose (Year 5) – from West Primary School

Table of contents:

1. About the project

The Primary Maths and Social Justice (PMSJ) research project was a collaboration between three lead researchers and six teacher researchers that took place in two different primary schools in Greater London between November 2021 and July 2022.

1.1. Overview

The project set out to explore how primary school teachers can pursue an interest in social justice issues (often cited as a reason for wanting to become a teacher in the first place) in teaching mathematics. We explored the potential of a model of participatory action research (PAR), which we have previously established (Wright, 2021; Wright, et al., 2022), for building and maintaining early career teachers' agency and self-efficacy in developing their own practice. We drew on a conceptualisation of teaching mathematics for social justice (TMSJ) to explore ways of developing students' critical mathematical understanding and collective agency in primary school classrooms (Wright, 2016; Wright, 2017). We see these two dispositions towards mathematics as vital for enabling today's learners to play a future role in addressing the environmental, economic and social challenges facing our society, reflecting recent calls for a more humanistic school curriculum (OECD, 2018; UNESCO, 2015). We anticipated the project would help us develop the concept of 'socio-mathematical agency' (SMA), which we define as the ability to use mathematics effectively to argue collectively for social change. Through exploring how students' critical mathematical understanding and collective agency can be measured/assessed/developed, we hoped to develop a better understanding of how SMA can be operationalised in the classroom.

1.2. Aims

The main research question was: *How can primary school teachers maintain and build upon their initial interest in addressing social justice issues through their teaching of mathematics?*

There were three specific aims:

1. To develop effective strategies that can be used by teachers in primary schools to enhance students' critical understanding of mathematics and collective mathematical agency.
2. To establish mechanisms and structures that enhance early career primary school teachers' agency in tackling social justice issues in mathematics lessons.
3. To explore how students' critical understanding of mathematics and collective mathematical agency can be measured/assessed/developed.

We outline in section 1.5 below how we addressed the three specific aims of the project.

1.3. Background

The recent Covid-19 pandemic highlighted the importance of individuals' understanding of mathematical concepts, such as exponential growth and moving averages, to make sense of complex data presented in the media, and hence make rational decisions about their own behaviour that take account of health risks to themselves and to others. This reinforces calls from inter-governmental policy-making organisations, such as the Organisation for Economic Co-operation and Development (OECD, 2018) and the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2015), for more humanistic school curricula that cultivate the collective knowledge and critical understanding that are required to address the environmental, economic and social challenges facing our world.

Mathematics is essential in solving real life problems and hence has a critical role to play in tackling many of the crises we face as a global society (Skovsmose, 2021). Gutstein (2006) highlights how a mathematics curriculum that emphasises reasoning, communication and problem-solving is necessary for empowering mathematics learners and enabling them to develop the agency needed to apply their knowledge to solving

real life problems. Developing powerful mathematics knowledge requires providing students with opportunities to experience the processes that mathematicians go through in developing new knowledge, including working collaboratively (since most new mathematical knowledge is generated by teams), conjecturing, reasoning, justifying and explaining (Mason, et al., 1985; Schoenfeld, 2012). Abstract knowledge on its own should not be considered as powerful, since its power depends on the agency of the learner to apply and use it for the public good (Manyukhina & Wyse, 2019). We refer *to 'socio-mathematical agency'* as the ability to use mathematics to argue collectively for social change (Wright, 2022). We believe developing socio-mathematical agency (SMA) is the most important contribution that the mathematics curriculum can make to cultivating the collective knowledge and critical understanding required to address the environmental, economic and social challenges facing our world.

Manyukhina and Wyse (2019) distinguish between two aspects of leaner agency: a 'sense of agency' (feeling in control of one's own learning) and 'agentic behaviour' (exercising control through one's actions). We see socio-mathematical agency (SMA) as having three components and how each of these relates to learners' sense of agency and agentic behaviour is summarised in the table below:

Component of SMA	How SMA relates to 'sense of agency'	How SMA relates to 'agentic behaviour'
1	Appreciating the links/applications between mathematics and social justice issues.	Using mathematics to better understand social justice issues.
2	Appreciating the power of mathematics to support an argument for social change.	Using mathematics to support an argument for social change.
3	Appreciating the value of working together in mathematics to solve problems.	Working together effectively in mathematics to solve problems.

1.4. Context

The three lead researchers have a variety of expertise in teaching, teacher education and research:

- Pete has taught mathematics for 15 years in a range of secondary schools and has tutored PGCE Mathematics student teachers for 11 years. His research has involved collaborating with teachers in exploring how theories of TMSJ can be translated into classroom practice.
- Caroline has taught mathematics for several years in schools and colleges across all phases, including mainstream and special schools. Her research has involved supporting students who struggle with mathematics including low attainers and those with special educational needs and disabilities.
- Joel has taught in primary schools for several years. He is completing a Masters' degree in Education at the University of Cambridge.

The six teacher researchers have a range of teaching experience across different year groups in two neighbouring primary schools in Greater London (all names below are pseudonyms).

- David taught a Year 2 class at East Primary School. He was in his 2nd year of teaching.
- Emma taught a Year 1 class at East Primary School. She was in her 1st year of teaching.
- Kate taught a Year 1 class at East Primary School. She was in her 1st year of teaching.
- Layla taught a Year 6 class at East Primary School, where she was the Mathematics Coordinator. She was in her 2nd year of teaching.
- Aidan taught a Year 2 class at West Primary School, where he was the Mathematics Coordinator. He was an experienced teacher.
- Rose taught a Year 5 class at West Primary School, where she was the Science Coordinator. She was in her 3rd year of teaching.

Both schools are voluntary aided primary (age 3-11) schools in Greater London with a relatively high proportion of students from minority ethnic groups. The schools neighbour each other and have a history of working collaboratively on curriculum projects and initiatives.

1.5. Research methods and methodology

The project's methodology was based on a model of participatory action research (PAR) that we have previously established (Wright, 2021; Wright, et al., 2022). The model involves a genuine collaboration between academic researchers and teacher researchers that recognises both the research expertise of the former and the latter's in-depth knowledge of the classroom situation. It offers a systematic and critical approach to exploring and developing classroom practice which seeks positive social change and takes as its starting point that existing practice should not be taken as given. A research team was established with three lead ('academic') researchers and six teacher researchers. In accordance with the participatory nature of the model, the teacher researchers' role included discussing and agreeing the final research design, with the lead researchers playing a largely facilitative role.

There was an introductory research team meeting during which the final research design was agreed. We agreed at this meeting that all researchers would maintain a research journal to capture the development of their thinking and classroom practice over the course of the project. The research journals were used to record reflections on discussions during research team meetings and reflections on responses of students during research lessons. They served as useful prompts to facilitate evaluations and further discussions during meetings. The introductory meeting was followed by two PAR cycles, each of which began with a research team meeting that focused mainly on planning the research lessons and concluded with a research team meeting that focused mainly on evaluating the research lessons. The teacher researchers worked in pairs to complete the detailed follow-up planning of research lessons, with each pair being supported by one of the lead researchers. Further details of research team meetings can be found on section 1.7.

Data were collected through audio-recording the two research team meetings that focused on evaluating the research lessons and transcribing these recordings. Each teacher researcher (in pairs where possible) was interviewed near the beginning and end of the project by one of the lead researchers (see section 1.8). These interviews were also audio-recorded and transcribed. Thematic analyses were then carried out on these transcripts by the lead researchers in order to assess the effectiveness of strategies used by the teacher researchers in enhancing students' SMA (research aim 1) and to assess the impact of the project on the teachers' thinking and practice (research aim 2). A survey was also administered twice, near the beginning and end of the project, for all students in the six teachers' classes (see section 1.6). Statistical analyses were carried out on the collated responses in order to assess how SMA could be measured and developed (research aim 3).

1.6. Student surveys

The survey was designed as a tool to assess/measure students' *sense of* socio-mathematical agency (SMA), defined as 'the ability to use mathematics effectively to argue collectively for social change'. Note that 'sense of agency' is more appropriately assessed through a self-reporting survey, whilst 'agentic behaviour' is better assessed through the evaluation of research lessons (see section 1.3 above). The project aimed to develop a survey that was suitable for this purpose and to explore its efficacy in assessing the development of SMA over the course of the project. The survey was administered twice to all students in all six classes, once near the beginning, and once near the end of the project. Students were invited to rank the extent to which they agreed with a series of statements relating to SMA and then invited to provide a comment to explain why they chose to rank each statement in this way. Particular consideration was given to the language used in the survey to ensure it was accessible to students ranging from Year 1 up to Year 6 (ages 5 to 11).

It was decided to use a 4-point Likert scale (strongly disagree, disagree, agree, strongly agree) to avoid the tendency for participants to opt for the middle value on a Likert scale. It was also decided to start with 'strongly disagree' to allow for more progress between the two surveys, as it was felt that there was a tendency on a Likert scale to choose one of the earlier options on the scale. As SMA was seen as having three components, it was felt that six questions would be enough with two questions related to each of the three components. This would allow us to test for the reliability of the survey by exploring the relationship between the responses to questions targeting the same component. The three lead researchers initially came up with one statement targeting each component as shown in the table below:

Component of SMA	**Initial statement**
1. Appreciate the links/applications between mathematics and social justice issues.	*Maths is always used to make things clearer to people.*
2. Appreciate the power of mathematics to support an argument for social change.	*Maths can be used to make the world a better place.*
3. Appreciate the value of working together in mathematics to solve problems.	*It is good to solve maths problems with other people.*

These statements and the design of the survey were then discussed in detail with the teacher researchers during Research Group Meeting 2, resulting in the development of six statements to be used in the survey and modifications to the layout of the survey. Shortly after the meeting, Joel had an opportunity to trial the survey with some Year 2's who were not involved in the project and the responses informed a subsequent meeting of the lead researchers at which further minor changes were made to the language in the statements. The final six statements included in the survey are shown below and the agreed layout of the survey can be seen in Appendix 1:

1. Maths helps people to understand the world better.
2. It is good to solve maths problems with other people.
3. Maths can be used to make the world a better place.
4. You can do more in maths when you work with others.
5. Maths can be used to mislead people.
6. You can use maths to help you explain something.

Statements 1 and 5 above relate to component 1 of SMA (see earlier table).
Statements 3 and 6 above relate to component 2 of SMA (see earlier table).
Statements 2 and 4 above relate to component 3 of SMA (see earlier table).

Protocols were also agreed for how the survey would be administered to students. These included allowing teachers and teacher helpers to read the statements to Key Stage 1 students and to scribe their explanatory comments on their behalf. The protocols were incorporated into the guidance that appeared on the first page of the survey (see Appendix 1). Teacher researchers were provided with printed surveys that included unique identifiers which they used to ensure survey responses from the first and second surveys could be matched for each student. Note, to ensure anonymity, the completed surveys were sent directly to Pete who collated the responses and shared them with teacher researchers without the unique identifiers.

1.7. Research team meetings

Five meetings of the research team were held in total (see timeline below), although the lead researchers met online on several other occasions to plan how to facilitate the project and research team meetings.

Timeline for the research project (November 2021 to July 2022):

Date(s)	Action	Notes
30th Nov	Research Team Meeting 1	In person at East Primary School – introductions; engaging with theory; discussing and agreeing final project design
12th Jan – 14th Jan	Interview 1	First series of (mostly) online interviews of teacher researchers by lead researchers
18th Jan	Research Team Meeting 2	In person at East Primary School – research journals; student surveys; students/parents' consent; planning Research Lesson 1;
Late Feb	Student Survey 1	Teacher researchers administer survey for first time to all students in their classes
Early Mar	Research Lesson 1	Teacher researchers teach first series of research lessons to their classes
22nd Mar	Research Team Meeting 3	Online meeting – feedback on administering surveys; evaluating Research Lesson 1 (individual presentations, common themes)
24th May	Research Team Meeting 4	In person at East Primary School – review of aims of project; planning Research Lesson 2
Late June	Research Lesson 2	Teacher researchers teach second series of research lessons to their classes
5th July	Research Team Meeting 5	Online meeting – evaluating Research Lesson 2 (individual presentations, common themes)
Early July	Student Survey 2	Teacher researchers administer survey for second time to all students in their classes
12th July – 19th July	Interview 2	Second series of (mostly) online interviews of teacher researchers by lead researchers

Research Team Meeting 1 included a presentation by Pete of some of the theoretical ideas underlying the project, including a summary of previous findings from projects around TMSJ, the concept of SMA and principles/methods relating to PAR methodology. This was followed by reflecting on how these ideas relate to current practice, focusing on opportunities and constraints faced by the teacher researchers. There was also a discussion around finalising the research design and ethical approval, including how to seek informed consent from students and parents.

Research Team Meetings 2 and 4 focused mainly on planning Research Lessons 1 and 2 respectively. There were also opportunities in these meetings to deal with logistical matters, e.g. around administering the surveys, and to review progress on the project. The research team decided that teacher researchers should work in the following pairs to complete the detailed follow-up planning of research lessons, with each pair supported by one of the lead researchers:

- Emma (Year 1, East PS) and Kate (Year 1, East PS), supported by Joel
- David (Year 2, East PS) and Aidan (Year 2, West PS), supported by Caroline
- Rose (Year 5, West PS) and Layla (Year 6, East PS), supported by Pete

Research Team Meetings 3 and 5 focused mainly on evaluating Research Lessons 1 and 2 respectively. It was agreed that each teacher researcher would present an evaluation of their lesson to the rest of the team based on their answers to the following four questions (note a fifth question* was added for Meeting 5):

- What maths learning is taking place?

- How successfully did the students work collaboratively and did they see this as valuable?
- What were the opportunities for maths and how did this reinforce the children's mathematical skills and understanding?
- In what ways were numbers used to attribute value?
- To what extent did the students appreciate the application of maths in a meaningful way? *

1.8. Teacher researcher interviews

The same pairs as shown above were used to organise the interviews of teacher researchers by lead researchers. Most of these interviews were held online, although some of Joel's interviews were held as face-to-face meetings in East Primary School. The interviews with pairs of teacher researchers were approximately 30-40 minutes in length, and those with individuals approximately 15-20 minutes in length. The interviews were semi-structured, with agreed initial questions and allowing for appropriate follow-up questions such as *'tell me more'*. They were conducted in an empathetic manner, i.e. the need to establish rapport was recognised and encouraging responses such as *'that's interesting'* were seen as beneficial. The initial questions were discussed and agreed by the lead researchers with the aim of getting teacher researchers to reflect on their developing thinking and classroom practice, and experiences relating to aims of the project (see research aims 1 and 2 in section 1.2).

These were the initial six questions asked to each teacher researcher in the first series of interviews:

a) What motivated you to take part in this project? [Why are you interested in the project? Why are you interested in SJ?]
b) How do you think social justice relates to your current classroom practice with regards to teaching mathematics? [Clarify meaning of SJ. Where are you now? Not limited to mathematics lessons]
c) How do you think student agency relates to your current classroom practice with regards teaching mathematics? [Clarify meaning of student agency. Where are you now?]
d) What ideas do you have for activities or strategies that you might try out that focus on social justice related to teaching mathematics? [Activities/strategies? could be in the classroom or outside, e.g. sports council]
e) What challenges do you think you will face? What are the opportunities?
f) What do you hope to get out of your participation in this project?

These were the initial eight questions asked to each teacher researcher in the second series of interviews:

a) What impact has the project had on your students? [What was it that made a difference? Meaningful context?]
b) What impact do you think the project has had on your thinking? [About student agency? About critical mathematical understanding?]
c) What impact do you think the project has had on your classroom practice? [What do you think has had the biggest impact? How do you know?]
d) Are there any other ways in which you have benefited from participating in the project?
e) Has the project had any impact on the way you teach mathematics during designated maths lessons? [Why/why not? How has this changed? What prompted it to change?]
f) What challenges/constraints have you managed to overcome through the project? [What helped you to do this? What challenges/constraints still remain?]
g) What other opportunities do you see for using/integrating maths across the curriculum?
h) Has the project generated interest amongst colleagues? [Who has shown an interest? What were they interested in?]

1.9. Ethics approval

Approval for conducting the research was granted by the UCL Research Ethics Committee (approval number REC1562). In gaining this approval, the following procedures were adopted to address any ethical issues that might arise:

- Informed consent was obtained from the teacher researchers by providing them with an information leaflet and asking them to complete a consent form (countersigned by their headteacher) before agreeing to participate in the project (both included in Appendix 2). It was made clear that participation was entirely voluntary, and that they were able to withdraw at any point, or request for their data to be withdrawn at any point, without detriment.
- Informed consent was obtained from the students and their parents/carers for participating in the surveys on an opt-out basis. It was made clear that participation in the surveys was entirely optional and clear instructions were provided in case students/parents/carers had any queries or wished to decline from participating in the survey (see information in Appendix 2).
- Every effort has been made to ensure that participants in the research cannot be identified from the data, including conducting the surveys anonymously, replacing all references to schools/teacher researchers/third parties in the transcripts of meetings/interviews and research findings/reports with pseudonyms, and storing data securely.

1.10. Teaching activities and strategies

Initial ideas for the research lessons were discussed during Research Team Meetings 2 and 4. The teacher researchers then worked together in the following pairs to complete the planning of the research lessons: Emma and Kate (Year 1); David and Aidan (Year 2); Rose and Layla (Years 5 and 6).

1.10.1. Research lesson 1

Year 1

In one class students had to vote for a phonics game. They were given a choice of two games. Some students did not vote, and this led to some discussion using addition and subtraction. The teacher used a majority vote to make the decision on which game to play. The teacher then facilitated a discussion on whether this was fair. Several different views came up and there was also a discussion of whether there was a fairer way to make the decision. The students enjoyed seeing numbers used in a meaningful way.

In the other class, students had to vote for activities to have during Golden Time. Again there was some discussion about different voting systems and how children in Year 1 could be introduced to these.

Year 2

The activities took place during Science Week. The focus was on air pollution and how it impacts climate change. The main maths activities involved different representations, such as pictograms and tally charts. The children also practised counting in groups of five with the tally charts and the pictograms.

The class first talked about the ULEZ (Ultra Low Emission Zone) charges, as this was quite topical. This led to discussions about when is the busiest time of day locally and why this might be. What might the impact of this be on pollution near the school and as students are walking to school? This led to an activity in which students collected data on how they got to school that day. This was done with the whole class, using a tally chart. The students were surprised that so many of them came to school by car.

The teacher then asked the class, “Should there be a charge for everybody?” This led to a discussion about fairness and whether students who did not come to school by car should pay a charge for polluting the local environment. There was also some discussion about using buses and whether this was better than coming

by car. Also, should people travelling by bus pay the same charge as someone using their own car? What about electric cars? Some students felt that electric cars were very expensive and so only some people could afford them. This was not fair.

Overall, the issue of fairness became a big focus, as did the problem with voting systems where there were limited choices. The children were very excited to see how maths could be used to argue for things that really mattered. However, some of the concepts, such as those around democracy were hard for some of the students to understand.

Years 5 and 6

The focus was on the mean using different contexts. First the idea of the mean as an average was introduced and a discussion of how this can be used in real life situations.

Students worked in groups and were encouraged to work collaboratively. They started the activity by giving each student a different number of cubes. This raised the issue of fairness. Through discussion, students came to realise that it would be fairer to share all the cubes out equally between everyone in the group. This led to a discussion of how this could be done and resulted in students identifying the method for calculating the mean. The students were then asked to discuss other issues where finding the mean would result in a fairer distribution of resources. For example, the distribution of emergency supplies in Ukraine was discussed, as was average goals scored by the local football team over the season.

In the other class, the students explored biomes (an area classified according to the species that live in that location), because that was their current topic in geography. The students were given a list of things that can affect them in their own environment (e.g. deforestation, pollution, climate change) and they had to rank them, in order according to which ones cause the most damage. They then had to apply this ranking to a case study and discuss potential outcomes. This activity led to a lot of discussion and debate, even though the mathematics was quite straight forward. Working collaboratively was a challenge, as the students had very strong opinions on things. In discussions, it was suggested that the students could perhaps have been introduced to different voting systems, in order to develop their understanding further.

1.10.2. Research lesson 2

Year 1

The activity focused on the use of an area of the playground with specific bits of equipment, such as football goal posts, that is usually used by Year 2-6 only (one year group each day). The teachers created a map of the playground and split it into four areas. The students then had to try to create a timetable that was fair. There were six classes and five days in the week. To make the activity more inclusive, a range of resources was provided to ensure access for all the children.

The students worked in groups. They were particularly motivated by the fact that this discussion could make a real difference, because their findings could be taken to the head teacher and could be discussed in a school council meeting. The fact that this was a real application of maths led to some students feeling more positive about themselves as mathematicians. The students also had a lot to say about social justice and fairness. The problem was not simple and led to some very interesting mathematical discussions.

Year 2

The activity was based on a book called “The chimpanzees of Happytown”. The focus was on what democracy means, as this had come up as an issue in the first research lesson. There are many ideas in the book which were discussed as the book was read with the whole class (e.g. caring for the environment, working together and democracy).

This led to an activity on voting. The students had to put forward ideas for change from either those put forward in the book or issues related to school life, such as having a shorter school day. There were five groups and each group had to put forward a persuasive argument for their proposal. They then had to vote, but they were not allowed to vote for their own group. Before the voting took place, the teacher discussed the fact that each vote counts, so each student should think carefully about how to vote. Counters were used for placing the votes, rather than a show of hands.

A tally chart was used to record the voting. The class then discussed different ways that the voting totals could be represented. The students were particularly interested in discussing issues around the voting system and how they might have changed their vote if they had known how close some of the voting was going to be. It was suggested that an activity like this could lead to a piece of persuasive writing, because the students could see the power of argument and the power of the maths.

Years 5 and 6

The ideas were developed from the first activity (from Research Lesson 1).

In one class, they continued to develop understanding of the mean. Initially, students explored the distribution of aid in Ukraine. This led to discussions about social justice more generally and how it related to the students' own lives and interests. The students worked in groups to choose a social justice issue that they wanted to investigate (e.g. deforestation, gun laws in the USA, animal rights and poaching). The students did some research to find data on their chosen topics. They then swapped their investigations and another group continued to find data. The students could then present their findings to the rest of the class.

In the other class, a "Conundrum" was set up as a basis for discussion. The lesson focused on percentages and mass. The scenario was that there was a street that had been littered with around 200 kilograms of litter. There were three ways that the litter had been dumped. One of the amounts was given as a percentage of the whole, and another was given as a mass. The last bit of information related to the amount of litter deposited by 20 houses, with an average of 2kg deposited by each household. The question was how to pay for the clean-up in a fair way. The students then had to present their distribution to the class and argue for their approach.

2. Statistical analysis of student survey responses

As the main aim was to test the efficacy of the survey in measuring SMA, the statistical analysis focused to a large extent on testing for validity and reliability (see sections 2.1 and 2.2 below). Having established the validity and reliability of the survey, we went on to explore what the outputs might tell us about differences in students' SMA across the different key stages and between the start and end of the project (see section 2.3 below).

2.1. Validity of surveys

The validity of the survey is the extent to which it genuinely measures what we claim that it will, i.e. the SMA of students. Walker (2010, p.52) highlights three aspects of validity: 'face validity', i.e. whether the measurement tool looks, on the face of it, as if it will work; 'predictive validity', i.e. whether it can predict future behaviour; 'criterion validity', i.e. whether it distinguishes between those exhibiting different characteristics. The face validity of the survey was enhanced by extensive discussions in Research Group meetings to ensure a shared understanding of the concept of SMA (Meeting 1) and relating this to the design of the survey (Meeting 2). The predictive validity depends on whether findings from the analysis of the survey triangulate with the findings from the thematic analyses of the interviews and meetings (see section 4). The statistical analysis that follows in this section aims to test the criterion validity of the survey by looking at the extent to which the rankings that students gave to the statements correlate with the characteristics exhibited by the students that can be deduced from their explanatory comments. This is based on the assumption that these comments might provide more insight into students' sense of SMA than their rankings alone (see section 3).

We (Pete and Caroline, two of the lead researchers) began by looking at the comments students had made explaining their ranking for each statement without having access to the rankings. We then attempted to predict what we thought an appropriate ranking would be for each statement based on what the accompanying comment suggested to us about the characteristics exhibited by the student. We then looked for a correlation between these predicted rankings and the actual rankings made by the students. Given the time needed for the two of us to agree on a predicted ranking for each comment, we chose to do this for one class only and chose Aidan's class for several reasons. Firstly, as this was a Year 2 class in an inner-city school with a relatively high proportion of bilingual learners, there were likely to be issues with understanding the language (which was a key consideration in the design of the survey). Secondly, there was a relatively high number of students in this class who had included comments in their responses to both surveys. Thirdly, from a preliminary scan of the data, we had identified Aidan's class as being potentially interesting as there appeared to be a noticeable increase in rankings from Survey 1 to Survey 2.

There were several issues we needed to resolve in predicting rankings in this way. Firstly, not every ranking was accompanied by a comment and hence we were only able to analyse students' responses that included a ranking and a comment. Secondly, some comments demonstrated clearly that students had misunderstood the statement (i.e. interpreted it in a different way to what we intended) making it impossible for us to make a prediction. Instead, we used the code 'M' to highlight that we felt the student had misunderstood the statement (see examples of these comments below). Thirdly, the nature of some comments did not allow us to make any inferences about the characteristics displayed by the students, e.g. the comment might have simply rephrased the statement or indicated how confident the student was in their ranking. We used the code 'X' for these comments (see examples below). All examples below are in response to Statement 3 (*Maths can be used to make the world a better place*).

Examples of students' comments coded 'M' (misunderstood statement), suggesting students misinterpreted the statement as relating to their personal wellbeing:

- *Because maths is really good for your brain.*

- *If you know maths you can move up.*

Examples of students' comments coded 'X' (not possible to infer):

- *Because it's good for maths to do.*
- *I'm not sure.*

The number of responses where we were able to make a prediction is shown in the tables below:

Survey 1	Number of completed surveys	Number of comments made	Responses with no comment	Responses coded 'M'	Responses coded 'X'	Number of predictions possible
Question 1	24	24	0	6	1	17
Question 2	24	24	0	0	2	22
Question 3	24	24	0	5	8	11
Question 4	24	23	1	2	1	20
Question 5	24	13	11	4	5	4
Question 6	24	23	1	6	10	7

Survey 2	Number of completed surveys	Number of comments made	Responses with no comment	Responses coded 'M'	Responses coded 'X'	Number of predictions possible
Question 1	21	20	1	1	0	19
Question 2	21	21	0	0	0	21
Question 3	21	18	2	3	2	13
Question 4	21	20	1	0	2	18
Question 5	21	12	9	2	2	8
Question 6	21	20	1	3	3	12

Before looking at the correlations between predicted and actual rankings, it is worth commenting on the above. There is a relatively high frequency of comments accompanying statements 1, 3 and 6 that were coded 'M', particularly on Survey 1, indicating that there were issues with several students incorrectly interpreting the language in the statement. This suggests the language used in these statements should be reviewed if the survey is to be used again in future, and also highlights the limitations of any findings that emerge from our analysis. However, for these three statements, along with statements 2 and 4, we were able to make enough predictions to look for a correlation with actual rankings. For statement 5, almost half of student respondents did not make an explanatory statement, suggesting a major issue in interpreting the language within this statement. Indeed, this was a statement we had debated at length during meetings and with which we anticipated some problems (highlighting the difficulty in communicating quite complex ideas in simple language). In total, we were only able to make 12 predicted rankings across both surveys and this needs to be considered carefully when interpreting any statistical analyses relating to survey question 5.

Given this caveat and the ordinal nature of the data, we carried out a test for correlation, using Spearman's Correlation Coefficient (Spearman's Rho), between the actual rankings and our own predicted rankings based on the comments made by students in Aidan's class on both surveys combined. The results of these tests are summarised below:

Question/statement	Sample size (N)	Correlation coefficient (r_s)	Significance (p, one-tailed)
Statement 1	36	.575	< .001
Statement 2	43	.686	< .001
Statement 3	24	.787	< .001
Statement 4	38	.524	< .001
Statement 5	12	.872	< .001
Statement 6	19	.406	.042

The results show a significant correlation ($p < .05$) between predicted and actual rankings for all 6 questions. Taking into account the difficulty in interpreting the language in the statements highlighted above, this demonstrates a reasonably high level of criterion validity within the survey. In other words, once students were able to access the language, the survey appeared to measure what it was intended to measure. Interestingly, despite the issues highlighted above, Question 5 appeared to have the highest correlation coefficient, perhaps because the sample was limited to those students who were able to access the relatively complex language in the statement. It is worth pointing out that the significant correlation between predicted rankings and actual rankings depends upon two conditions being satisfied: the researchers correctly interpreting the students' comments; and the characteristics exhibited by the students correctly predicting the actual rankings. It is only the second of these two conditions we are interested in for criterion validity and the test results allow us to arrive at the above conclusions.

2.2. Reliability of surveys

The reliability of the survey is the extent to which it works consistently within itself, i.e. 'internal reliability', and over time, i.e. 'stability' (Walker, 2010, p.52). The two surveys were conducted only 6 months apart and later results (see section 2.3.2) suggest that, with the exception of students in Aidan's class and the results for Question 5, there was no significant difference between students' rankings in the two surveys, supporting an argument for the stability of the survey. We tested the internal reliability of the survey by looking for correlations, using Spearman's Correlation Coefficient (Spearman's Rho), between students' responses (rankings only for all students who responded to both questions) to all six questions. Since all six questions were designed to measure SMA (with a higher ranking demonstrating a higher level of SMA), we would expect to see a significant positive correlation between all six questions as an indication of the internal reliability of the survey. Given that we identified three components of SMA, and designed two questions for each component, we would expect to see a particularly strong correlation between the following pairs of questions:

- Questions 1 and 5 both relate to component 1 of SMA (see section 1.5).
- Questions 3 and 6 both relate to component 2 of SMA (see section 1.5).
- Questions 2 and 4 both relate to component 3 of SMA (see section 1.5).

We have chosen to report in detail on the results for survey 2, which showed generally higher and more significant correlations than survey 1, as we feel this a fairer test for internal reliability as students were more likely to have a better developed sense of SMA towards the end of the project. However, we have included the results for survey 1 as well (for reference).

The results of the tests for correlation, using Spearman's Correlation Coefficient (Spearman's Rho), between students' rankings of different statements on survey 2 are reported in the table below. Note that, in the table, 'S2 Q1' refers to students' responses to Survey 2 Question 1 (which asked students to rank the extent to which they agreed with statement 1), etc. The shaded cells indicate where there was a significant correlation ($p < .05$) between responses to two questions. The bold font highlights the relationship between the two questions relating to the same component of SMA.

Correlations - Survey 2		S2 Q2	S2 Q3	S2 Q4	S2 Q5	S2 Q6
S2 Q1	Corr. coeff., r_s	0.007	0.544**	0.202**	**-0.013**	0.442**
	Significance, p	.467	< .001	.010	**.441**	< .001
	Sample size, N	139	134	134	**132**	132
S2 Q2	Corr. coeff., r_s		0.163*	**0.482****	-0.200*	0.223**
	Significance, p		.030	**< .001**	.010	.005
	Sample size, N		134	**134**	133	133
S2 Q3	Corr. coeff., r_s			0.383**	0.059	**0.511****
	Significance, p			< .001	.252	**< .001**
	Sample size, N			131	129	**129**
S2 Q4	Corr. coeff., r_s				-0.080	0.317**
	Significance, p				.183	< 0.001
	Sample size, N				131	131
S2 Q5	Corr. coeff., r_s					-0.068
	Significance, p					0.221
	Sample size, N					131

** Correlation is significant at the 0.01 level (1-tailed)

* Correlation is significant at the 0.05 level (1-tailed)

The results show that there is no significant correlation between Question 5 and Questions 1, 3, 4 and 6. There was a significant correlation between Question 5 and Question 2, however this correlation was negative which is the opposite of what we would expect if there were internal reliability. This raises further concerns about the efficacy of Question 5 in addition to those already highlighted (see section 2.1). If we ignore Question 5, of the remaining 10 relationships between pairs of variables, all but one showed a significant positive correlation between responses, indicating high levels of internal reliability. Four of these nine correlations were strong ($r_s > 0.4$), four were moderate ($0.2 < r_s < 0.4$), and one was weak ($r_s < 0.2$). It is not clear why there was no significant correlation between Questions 1 and 2 (as we would have expected). There were relatively strong ($r_s > 0.4$) and significant ($p < .001$) correlations between Questions 3 and 6, and between Questions 2 and 4 (displaying two out of the three highest correlation coefficients). Since these pairs of questions were designed to measure the same components of SMA, this provides further evidence to support the internal reliability of the survey. Interestingly, the strongest correlation was between Questions 1 and 3, which might possibly be explained by the similarity in language between the two statements (both contained the words 'world' and 'better'), despite them being designed to measure different components of SMA.

The table below shows test results for correlations between responses to different questions on Survey 1:

Correlations - Survey 1		S1 Q2	S1 Q3	S1 Q4	S1 Q5	S1 Q6
S1 Q1	Corr. coeff., r_s	0.065	0.332**	0.125	**-0.229****	0.237**
	Significance, p	.212	< 0.001	.061	**.003**	.002
	Sample size, N	155	153	154	**149**	153
S1 Q2	Corr. coeff., r_s		0.049	**0.350****	-0.203**	0.052
	Significance, p		.274	**< 0.001**	.006	.260
	Sample size, N		153	**154**	149	153
S1 Q3	Corr. coeff., r_s			0.098	-0.088	**0.365****
	Significance, p			.115	.144	**< 0.001**
	Sample size, N			152	147	**151**
S1 Q4	Corr. coeff., r_s				-0.221**	0.070
	Significance, p				.003	.196
	Sample size, N				149	153

S1 Q5	Corr. coeff., r_s		-0.037
	Significance, p		.328
	Sample size, N		149

** Correlation is significant at the 0.01 level (1-tailed)

* Correlation is significant at the 0.05 level (1-tailed)

2.3. Measures of (sense of) SMA

Given that we are reasonably confident about the validity and reliability of the survey with the exception of Question 5 (see sections 2.1 and 2.2), we decided to use the survey to explore whether there were any significant differences between Key Stage 1 and Key Stage 2 students' SMA (see section 2.3.1), and whether there was any significant increase in students' SMA over the course of the project (see section 2.3.2).

2.3.1. Differences in SMA across Key Stages

Given that the students in our sample were split between Years 1 and 2 (Key Stage 1) and Years 5 and 6 (upper end of Key Stage 2), we thought it would be interesting to see if there were any differences in responses between these two age ranges (representing students near to the beginning and end of their primary schooling respectively). We were particularly interested in the results from Survey 1 as this might give an indication of students' SMA before they took part in any lessons relating to the research project, which might be more representative of students in general. However, we have also included some results from Survey 2 for comparison. If KS2 students showed a higher SMA than KS1 students, then this might suggest that experiencing the primary school mathematics curriculum has a positive impact on students' sense of SMA. It should be noted, however, that the KS1 students had more support in completing the surveys (in most cases teachers and teacher helpers read the statements to students and scribed their responses) and this needs to be taken into account in explaining any differences.

We used the Mann-Whitney U Test to look for significant differences between students' survey responses to each question (excluding Question 5) across different Key Stages (the test is designed for independent samples and ordinal variables). The significance scores for each question on Survey 1 are shown in the table below (with those showing a significant difference shaded grey):

Comparison on Survey 1	Asymptotic Significance, p (2-sided test)
Distribution of Q1 response ranks across Key Stages	.052
Distribution of Q2 response ranks across Key Stages	.571
Distribution of Q3 response ranks across Key Stages	.444
Distribution of Q4 response ranks across Key Stages	< .001
Distribution of Q6 response ranks across Key Stages	.047

Detailed test results for the significant differences are given in the table below (note we have included Question 1 as the p-score was very close to .05, albeit slightly above).

Question (Survey 1)	N (KS1)	N (KS2)	Mean rank (KS1)	Mean rank (KS2)	Mann-Whitney U	Z-score	Significance, p
1	107	48	82.39	68.22	2098.5	-1.946	.052
4	106	48	86.05	58.63	1638.0	-4.092	< .001
6	105	48	81.44	67.28	2053.5	-1.986	.047

These results show that the students' responses for Questions 4 and 6 (and to a lesser extent Question 1) were significantly ($p < .05$) higher for KS1 students than for KS2 students. There were no significant differences for responses to Questions 2 and 3. This was somewhat contrary to what we expected and there are several possible explanations. It might be that the teachers and teacher helpers who supported the KS1 students with their surveys influenced their responses (although we did provide guidance to try

and avoid this). Or it might be that experiencing the primary school mathematics curriculum has a negative impact on students' sense of SMA. Or it may be that experiencing the school curriculum as a whole, and gaining wider real-life experiences, leads to a growing appreciation amongst students of the challenges that are faced by those wishing to bring about social change.

Results from the tests on Survey 2 were similar to Survey 1, with the students' responses for Questions 4 and 6 being significantly ($p < .05$) higher for KS1 students than for KS2 students (and no significant differences for responses to Questions 1, 2, 3):

Question (Survey 2)	N (KS1)	N (KS2)	Mean rank (KS1)	Mean rank (KS2)	Mann-Whitney U	Z-score	Significance, p
4	90	44	72.44	57.39	1535.0	-2.302	.021
6	88	45	72.14	56.96	1528.0	-2.310	.021

2.3.2. Differences in SMA across the two surveys

Survey 1 was conducted near the start of the project (before research lesson 1) and Survey 2 was conducted near the end of the project (after research lesson 2). We therefore thought it would be interesting to see if there were any significant differences between responses to each question on the two surveys as this might give an indication of any changes in students' SMA resulting from the project. We used the Wilcoxon Matched-Pairs Signed-Rank Test to look for significant differences between students' survey responses to each question across the two surveys (the test is designed for two sets of ordinal data outputs from the same participants). First of all, we looked at all students across the six classes (those that had completed both surveys). The test results for each question are summarised in the table below:

Group	Question	Total N	T statistic	z-score	Sig. p	Effect r
All students	1	126	1265.500	-1.243	.214	
All students	2	126	1783.500	-0.389	.697	
All students	3	120	1782.000	0.186	.853	
All students	4	120	1024.000	-1.150	.250	
All students	5	119	2696.500	5.044	< .001	0.462
All students	6	119	1592.000	-0.142	.887	

The results show that there were no significant changes to responses to Questions 1, 2, 3, 4, 6 across the two surveys (for all students). Given that these five questions appear to offer a valid and reliable measure of SMA (see sections 2.1 and 2.2), we can conclude that, when looking at all students, there were no significant increases in students' SMA between the start and end of the project. There was however a significant ($p < .05$) difference between responses to Question 5 across the two surveys (see shaded cells in the table above). Given the problematic nature of this question (highlighted in previous sections), we are limited in what we can conclude from this result. It is worth noting however that there was a medium effect size (r was between 0.3 and 0.5) for this increase suggesting that it had some practical significance. Whilst we cannot relate this to SMA, it might suggest that students consistently misinterpreted the statement as meaning something else and whatever this was showed a significant increase. This may be worth exploring further in the thematic analysis of the surveys (see section 3).

We went on to test for significant differences between survey responses to each question across the two surveys for different groups of students, again using the Wilcoxon Matched-Pairs Signed-Rank Test. We looked at Key Stage 1 and Key Stage 2 students and we also looked at the results for each class, as we felt that the teacher was likely to be a significant factor in the extent to which students' SMA increased. Most test results showed a similar significant ($p < .05$) increase in responses to Question 5 for all groups (see table below with the significant increases shaded grey).

Group	Question	Total N	T statistic	z-score	Sig. p	Effect r
Key Stage 1	5	82	1700.500	4.870	< .001	0.537
Key Stage 2	5	37	114.000	1.334	.182	
Kate's class (Y1)	5	27	324.500	3.360	< .001	0.647
Emma's class (Y1)	5	25	164.500	2.286	.022	0.457
Aidan's class (Y2)	5	19	46.500	1.996	.046	0.458
David's class (Y2)	5	11	19.500	1.947	.052	0.587
Rose's class (Y5)	5	7	3.000	-1.342	.180	
Layla's class (Y6)	5	30	73.500	2.066	.039	0.377

Note that the increase in responses to Question 5 was significant ($p < .05$) amongst KS1 students, but not KS2 students, and was significant for students in all classes except for David (Year 2) and Rose (Year 5). There were large effect sizes ($r > 0.5$) for KS1 students (note this effect size was larger than for all students) and for students in Kate's class and David's class (although the significance of the latter was slightly above .05). There were medium effect sizes for the increases in responses to Question 5 for students in Emma, Aidan and Layla's classes.

For all other questions, when we looked at different groups of students (by Key Stage and class), there were no significant differences in responses across the two surveys for most groups, mirroring the case for all students. However, there was an exception in Aidan's class, with the test showing a significant ($p < .05$) increase in responses to Questions 2, 3 and 6 (all with large effect sizes), with an increase in responses to Question 4 being only slightly below the significance threshold (see table below):

Group	Question	Total N	T statistic	z-score	Sig. p	Effect r
Aidan's class (Y2)	1	20	43.000	1.645	.100	
Aidan's class (Y2)	2	20	103.500	2.539	.011	0.568
Aidan's class (Y2)	3	19	81.000	2.579	.010	0.592
Aidan's class (Y2)	4	19	45.000	1.941	.052	0.445
Aidan's class (Y2)	6	17	66.000	3.025	.002	0.734

Given that these five questions appear to offer a valid and reliable measure of SMA (see sections 2.1 and 2.2), this suggests that students in Aidan's class were unique (out of the six classes) in showing a significant increase in SMA over the course of the project. This is definitely something worth exploring further in the thematic analyses of the surveys (see section 3), research group meetings and interviews (see section 4).

3. Thematic analysis of student survey responses

All of the responses (rankings and comments) from the student surveys were collated into a Microsoft Excel file. The responses for each class were entered into a separate sheet with the unique identifiers used to match responses from survey 1 and survey 2 for those students who completed both surveys. The responses were then read through several times for the purpose of becoming familiar with the data. The comments were then allocated a single code/category, using descriptive codes generated inductively. Each comment was considered in turn and either allocated an existing code or allocated a new code if none of the existing codes was adequate to describe the comment. The coding scheme is described further in section 3.1 below.

Thematic analyses were then conducted by focusing on interesting questions that had arisen from the statistical analysis. Firstly (see section 3.2.1 below), given that there appeared to be something unique about Aidan's class, which was the only one of the six classes to show a significant increase in sense of SMA over the course of the project, we decided to compare comments of students in Aidan's class on both surveys. We focused in particular on whether the comments for Questions 2, 3, 6 (and 4) concurred with the results of the statistical analysis (see section 2.3.2), i.e. significant increases (slightly below the significance threshold for Question 4) in rankings in responses, with large effect sizes.

Secondly (see section 3.2.2 below), despite the problematic nature of Question 5, there was a significant increase in rankings in responses to this question across the two surveys (for all students). There was a medium effect size overall for this increase, suggesting it had some practical significance worth exploring further (see section 2.3.2). The largest effect size was for Kate's class but, unfortunately, there were not enough comments made by students in Kate's class to make a thematic analysis meaningful. We decided instead to look at the comments for Question 5 in Emma's class, which had a medium effect size and a relatively high number of comments from students (particularly on Survey 2).

3.1. Coding scheme for student survey responses

We worked through each class in turn and began by looking at questions 1 and 5, relating to component 1 of SMA (see section 1.6). We then looked at questions 3 and 6, relating to component 2 of SMA, and finally questions 2 and 4, relating to component 3 of SMA. Most codes were classified as either 'positive', i.e. demonstrating relatively high levels of SMA, or 'negative', i.e. demonstrating relatively low levels of SMA. Some codes were considered to be ambiguous, i.e. they might demonstrate either high or low levels of SMA. Some examples of codes allocated to students' comments in response to Question 1 are shown in the table below. Note Question 1 asked students to explain the extent to which they agreed with the statement: *Maths helps people to understand the world better.*

Response	Code	Pos/Neg?	Description of code
Because maths helps scientists to discover things.	A	Positive	Acknowledges applications of maths to science/technology
It only helps you answer questions.	F	Negative	Argues that maths NOT applicable to real world
It helps us all to learn.	B	Pos/Neg	Expresses desirability of learning maths but with no justification

The complete list of codes/categories allocated to the survey responses (students' explanatory comments) for each question are included in the table on the next page.

Codes/categories allocated to the survey responses (students' explanatory comments) for each question:

Questions								
1	**2**	**3**	**4**	**5**	**6**	**Code**	**Pos/Neg**	**Description**
X	X	X	X	X	X	X		Inconclusive from comment (or question misunderstood)
A		A			A	A	Pos	Acknowledges applications of maths to science/technology
B		B			B	B	Pos/Neg	Expresses desirability of learning maths but with no justification
C		C				C	Pos/Neg	Recognises only indirect application to real world
D		D				D	Neg	Links learning maths to becoming more intelligent
E		E			E	E	Pos	Recognises direct application to real world
F		F			F	F	Neg	Argues that maths NOT applicable to real world
G		G				G	Pos/Neg	Argues that maths ONLY PARTIALLY applicable to real world
H		H	H			H	Neg	Argues that other subjects are more important
I						I	Pos	Acknowledges applications of maths to environment/susatainability
J		J				J	Pos	Recognises importance of maths to workplace
K		K				K	Pos	Recognises value of maths for making financial/life decisions
L		L				L	Pos/Neg	Recognises gatekeeper role of maths for study/jobs
M		M			M	M	Pos	Recognises maths is used is real life without giving explicit example
N		N		N		N	Pos/Neg	Argues maths can only be used in beneficial ways
O						O	Pos	Argues maths can help you share problems with others
P				P		P	Neg	Claims maths is about right and wrong answers
		Q		Q		Q	Neg	Claims maths can be confusing (not necessarily deliberate)
				R		R	Neg	Making errors seen as a bad thing
		S		S		S	Neg	Sees maths as something that can't be used to argue
		T		T		T	Pos	Believes people might be happy to understand more than others
				U		U	Pos	People can use maths to deliberately mislead
				V		V	Neg	People can't be misled as they can check the answers themselves
				W		W	Pos/Neg	People can think about maths in different ways
		YA				YA	Neg	Believes maths can help individuals but not world
		YB				YB	Pos	Argues maths can help people agree on solutions
		YC				YC	Pos	Argues maths can be used to measure progress in the world
		YD				YD	Neg	Expresses negative emotions towards maths
	YE	YE	YE			YE	Pos	Working together can help people learn/solve problems more efficiently
		YF				YF	Pos	Maths can be used to make things fairer
					YG	YG	Pos	Gives example of maths helping to explain real life situation
					YH	YH	Neg	Explaining something depends on your own understanding
					YI	YI	Neg	Believes maths not as much about explaining
					YJ	YJ	Pos	Using maths can help make your explanation convincing
					YK	YK	Pos	Refers to mathematical explanations of maths problems
					YL	YL	Pos	Acknowledges that words can be used in mathematical explanation
			YM		YM	YM	Pos	Refers to benefits of explaining in maths
	YN		YN		YN	YN	Pos	Explaining/working together makes maths more enjoyable
		YP				YP	Pos	Maths can be used to help others
	ZA		ZA			ZA	Neg	Believes other people can distract you from learning
	ZB		ZB			ZB	Neg	Believes other people can do the work for you and stop you learning
	ZC		ZC			ZC	Pos	Believes other people can help you understand
	ZD		ZD			ZD	Neg	Believes helping others can adversely affect your own learning
	ZE					ZE	Neg	Believes students might favour some (their friends) over others
	ZF		ZF			ZF	Pos	Acknowledges importance of learning to work collaboratively (in general)
	ZG					ZG	Pos/Neg	Expresses desirability of working with others but with no justification
	ZH		ZH			ZH	Neg	Expresses preference for working independently (individually)
	ZI		ZI			ZI	Pos	Believes working together helps you to engage with other methods/ideas
	ZJ					ZJ	Neg	Believes others can copy you/steal your answers
	ZK		ZK			ZK	Neg	Believes you can pick up misconceptions/misunderstanding from others
	ZL					ZL	Neg	Expresses concern that you can become over-reliant on others
			ZM			ZM	Pos	Believes working together helps you complete MORE work (more quickly)
			ZN			ZN	Neg	Believes working together means you complete LESS work (slower)
			ZO			ZO	Neg	Believes others may be reluctant to help you

3.2. Findings of thematic analyses of student survey responses

3.2.1. Comparison of survey 1 and 2 responses for students in Aidan's class

There were 20 students in Aidan's class who completed both surveys 1 and 2.

Questions 1 and 5 were related to appreciating the links/applications between mathematics and social justice issues (**component 1 of SMA**).

Question 1: Students were asked to explain the extent to which they agreed with the statement: *Maths helps people to understand the world better*.

All 20 of these students made a comment for Question 1. Whilst there was no significant increase in rankings for Question 1 (see section 2.3.2), the comments appeared to show a developing appreciation of the links/applications between mathematics and social justice issues (component 1 of SMA), amongst these 20 students. The number of students recognising a direct link/application of mathematics to real life ('positive' codes) increased from 6 to 12, whilst the number of students recognising only an indirect or partial link/application (ambiguous codes) decreased from 9 to 5, and the number not recognising any link ('negative' codes) decreased from 3 to 2 (see table below).

Code	Code description (allocated to comments in response to Question 1)	Survey 1	Survey 2
A	Acknowledges applications of maths to science/technology	2	4
E	Recognises direct application to real world	1	1
I	Recognises importance of maths to workplace	1	0
J	Recognises importance of maths to workplace	2	3
K	Recognises value of maths for making financial/life decisions	0	3
M	Recognises maths is used is real life without giving explicit example	0	1
Total for all above codes classified as 'positive'		**6**	**12**
B	Expresses desirability of learning maths but with no justification	6	1
C	Recognises only indirect application to real world	2	4
G	Argues that maths ONLY PARTIALLY applicable to real world	1	0
Total for all above codes classified as ambiguous ('positive' or 'negative')		**9**	**5**
D	Links learning maths to becoming more intelligent	1	1
F	Argues that maths NOT applicable to real world	1	0
H	Argues that other subjects are more important	1	1
Total for all above codes classified as 'negative'		**3**	**2**
X	Inconclusive from comment (or question misunderstood)	2	1

Based on their comments for Question 1, the following students from Aidan's class appear to have made some progress in developing an appreciation of the links/applications between mathematics and social justice issues:

	Survey 1 Comment (Question 1)	Code	Survey 2 comment (Question 1)	Code
Student 1	*Because my mum always says "do your maths homework".*	B (amb)	*Scientists use maths and mathematicians to learn about the world and go to space.*	A (pos)
Student 8	*It makes people smart.*	D (neg)	*If you didn't know how to count and you went to buy something, you would be confused.*	K (pos)
Student 15	*Maths isn't the whole world - I'm in the middle.*	G (amb)	*You need to understand numbers to help you in life.*	G (pos)
Student 21	*It helps us all to learn.*	B (amb)	*When you know maths, you can become smarter and know more about the world.*	C (amb)

Question 5: Students were asked to explain the extent to which they agreed with the statement: *Maths can be used to mislead people.*

Of the 20 students who completed both surveys, on Survey 1 only 6 students made a meaningful comment in response to Question 5, and on Survey 2 only 9 students made a meaningful comment. The remainder either left the comment blank or wrote a comment that was not related to the statement (coded X), reinforcing concerns already highlighted about the wording of this question. The number of students recognising that maths can be used to mislead people ('positive' codes) increased from 1 to 4, whilst the number of students who believed maths was about right and wrong answers and was therefore only problematic if an answer was correct ('negative' codes) remained at 5 (see table below). The number of inappropriate responses (coded X) decreased from 4 to 2 (see table below). This suggests that some students understood the question better on Survey 2 and exhibited some development in their sense of SMA (although the numbers were small).

Code	Code description (allocated to comments in response to Question 5)	Survey 1	Survey 2
U	People can use maths to deliberately mislead	1	4
Total for all above codes classified as 'positive'		**1**	**4**
Total for all above codes classified as ambiguous ('positive' or 'negative')		**0**	**0**
P	Claims maths is about right and wrong answers	3	1
Q	Claims maths can be confusing (not necessarily deliberate)	1	0
R	Making errors seen as a bad thing	0	2
S	Sees maths as something that can't be used to argue	0	1
V	People can't be misled as they can check the answers themselves	1	1
Total for all above codes classified as 'negative'		**5**	**5**
X	Inconclusive from comment (or question misunderstood)	4	2
	No comment made	10	9

Based on their comments for Question 5, the following student appears to have maintained an appreciation that mathematics can be used to mislead people:

	Survey 1 Comment (Question 5)	Code	Survey 2 comment (Question 5)	Code
Student 21	*They might be lying to you by writing the wrong answer on purpose.*	U (pos)	*Sometimes they just lie to you.*	U (pos)

… whilst these students appear to have gained such an appreciation from participating in the project:

	Survey 1 Comment (Question 5)	Code	Survey 2 comment (Question 5)	Code
Student 15	*Our brain is like a muscle and if you give up your brain will get lazy.*	X	*If you tell someone, who doesn't know the right answer, the wrong answer, they might believe you.*	U (pos)
Student 16	*Good, in-between and bad.*	X	*People can trick you if you don't know.*	U (pos)

Questions 3 and 6 were related to appreciating the power of mathematics to support an argument for social change (**component 2 of SMA**).

Question 3: Students were asked to explain the extent to which they agreed with the statement: *Maths can be used to make the world a better place.*

There were 9 students on Survey 1, which reduced to 6 students on Survey 2, who made an inappropriate comment (or no comment) in response to this question. Many of these comments were of the form "I don't know" or "I'm not sure". The remainder of the comments concurred with the significant increase in rankings for Question 3 (see section 2.3.2), i.e. they showed a developing appreciation of the power of

mathematics to support an argument for social change (component 2 of SMA) amongst these remaining 14 students. The number of students recognising a direct link/application of mathematics to real life ('positive' codes) increased from 1 to 8, whilst the number of students recognising only an indirect or partial link/application (ambiguous codes) decreased from 6 to 3, and the number not recognising any link ('negative' codes) decreased from 4 to 3 (see table below).

Code	Code description (allocated to comments in response to Question 3)	Survey 1	Survey 2
A	Acknowledges applications of maths to science/technology	1	5
E	Recognises direct application to real world	0	2
J	Recognises importance of maths to workplace	0	1
Total for all above codes classified as 'positive'		**1**	**8**
B	Expresses desirability of learning maths but with no justification	6	0
C	Recognises only indirect application to real world	0	2
L	Recognises gatekeeper role of maths for study/jobs	0	1
Total for all above codes classified as ambiguous ('positive' or 'negative')		**6**	**3**
F	Argues that maths NOT applicable to real world	1	2
H	Argues that other subjects are more important	2	0
Q	Claims maths can be confusing (not necessarily deliberate)	0	1
YA	Believes maths can help individuals but not world	1	0
Total for all above codes classified as 'negative'		**4**	**3**
X	Inconclusive from comment (or question misunderstood)	9	4
	No comment made	0	2

Based on their comments for Question 3, the following students from Aidan's class appear to have made some progress in developing an appreciation of how mathematics can be used to benefit the world:

	Survey 1 Comment (Question 3)	Code	Survey 2 comment (Question 3)	Code
Student 3	*Because maths is really good for your brain.*	B (amb)	*They can use it to go to space and learn more about the world (how it works) to make Earth better.*	A (pos)
Student 12	*I don't know.*	X	*Then you can do more science to make better things or the environment.*	A (pos)
Student 20	*I'm not sure.*	X	*Scientists can use maths to make solar cars.*	A (pos)
Student 26	*If you know maths you can move up.*	X	*People in the bank need to know maths to give people money.*	E (pos)

Question 6: Students were asked to explain the extent to which they agreed with the statement: *You can use maths to help you explain something.*

There were 7 students on Survey 1, which reduced to only 1 student on Survey 2, who made an inappropriate comment (or no comment) in response to this question. The number of students recognising the value of mathematics in generating an explanation ('positive' codes) increased from 11 on Survey 1 to 19 (all but one student) on Survey 2 (see table below). The comments therefore concurred with the significant increase in rankings for Question 6 found in the statistical analysis (see section 2.3.2), i.e. there was a developing appreciation of the power of mathematics to support an argument for social change (component 2 of SMA) amongst students.

Code	Code description (allocated to comments in response to Question 6)	Survey 1	Survey 2
A	Acknowledges applications of maths to science/technology	1	1
E	Recognises direct application to real world	0	4

YJ	Using maths can help make your explanation convincing	0	1
YK	Refers to mathematical explanations of maths problems	10	12
YL	Acknowledges that words can be used in mathematical explanation	0	1
Total for all above codes classified as 'positive'		**11**	**19**
Total for all above codes classified as ambiguous ('positive' or 'negative')		**0**	**0**
YI	Believes maths not as much about explaining	2	0
Total for all above codes classified as 'negative'		**2**	**0**
X	Inconclusive from comment (or question misunderstood)	6	0
	No comment made	1	1

Based on their comments for Question 6, the following students from Aidan's class appear to have developed an appreciation of how mathematics involves explaining ideas:

	Survey 1 Comment (Question 6)	**Code**	**Survey 2 comment (Question 6)**	**Code**
Student 7	*Don't know.*	X	*To explain something in class.*	YK (pos)
Student 10	*I don't know.*	X	*It can help you explain tricky answers.*	YK (pos)
Student 25	[no ranking or comment made]		*If you explain your answer, people believe you.*	YJ (pos)

Other students appear to have moved on from recognising that mathematics involves some explaining to developing some appreciation of the power of mathematics to support an argument for social change:

	Survey 1 Comment (Question 6)	**Code**	**Survey 2 comment (Question 6)**	**Code**
Student 13	*You would be like a computer: "8, 21, 16, 5715"*	X	*If you need to know voting stuff, you could use a tally chart.*	E (pos)
Student 15	*It can help you explain a maths question.*	YK (pos)	*If you're in a company and you explain how much things you need to make for the world, it's good - you could use a tally chart.*	E (pos)

Questions 2 and 4 were related to appreciating the value of working together in mathematics to solve problems (**component 3 of SMA**).

Question 2: Students were asked to explain the extent to which they agreed with the statement: *It is good to solve maths problems with other people*.

All 20 of the students who completed both surveys made an appropriate comment for Question 2. The number of students recognising the benefits of solving mathematics problems with other people ('positive' codes) increased from 9 on Survey 1 to 16 (all but 4 students) on Survey 2 (see table below). The comments therefore concurred with the significant increase in rankings for Question 2 found in the statistical analysis (see section 2.3.2), i.e. there was a developing appreciation of value of working together in mathematics to solve problems (component 3 of SMA) amongst students.

Code	**Code description (allocated to comments in response to Question 2)**	**Survey 1**	**Survey 2**
YE	Working together can help people learn/solve problems more efficiently	1	3
ZC	Believes other people can help you understand	8	12
ZI	Believes working together helps you to engage with other methods/ideas	0	1
Total for all above codes classified as 'positive'		**9**	**16**
Total for all above codes classified as ambiguous ('positive' or 'negative')		**0**	**0**
ZA	Believes other people can distract you from learning	0	1

ZB	Believes other people can do the work for you and stop you learning	3	1
ZD	Believes helping others can adversely affect your own learning	1	0
ZH	Expresses preference for working independently (individually)	1	0
ZJ	Believes others can copy you/steal your answers	2	1
ZK	Believes you can pick up misconceptions/misunderstanding from others	3	1
ZL	Expresses concern that you can become over-reliant on others	1	0
Total for all above codes classified as 'negative'		**11**	**4**
X	Inconclusive from comment (or question misunderstood)	0	0
	No comment made	0	0

Based on their comments for Question 2, the following students from Aidan's class appear to have developed an appreciation of the benefits of solving mathematics problems with other people, rather than seeing collaboration as hindering learning:

	Survey 1 Comment (Question 2)	**Code**	**Survey 2 comment (Question 2)**	**Code**
Student 2	*It's a bad thing to tell others the answers.*	ZB (neg)	*You can help each other.*	ZC (pos)
Student 13	*Because someone might give you the answers so it wouldn't be what you think - but peer marking is OK.*	ZB (neg)	*Then it helps you and each person can do a different method then work together.*	ZI (pos)
Student 15	*Someone might give you the wrong answer by accident then the teacher will tell you off for copying.*	ZK (neg)	*It's good to help people when they are stuck.*	ZC (pos)
Student 26	*Sometimes people just copy your answers.*	ZJ (neg)	*You can have different answers but use the information together to get the right one.*	YE (pos)

Question 4: Students were asked to explain the extent to which they agreed with the statement: *You can do more in maths when you work with others*.

19 of 20 of the students who completed both surveys made an appropriate comment for Question 4. The number of comments suggesting students agreed that you can do more in mathematics when working with others ('positive' codes) increased only slightly from 14 on Survey 1 to 15 on Survey 2 (see table below). The comments therefore did not concur with the increase in rankings for Question 4 (which was just below the significant threshold) found in the statistical analysis (see section 2.3.2). This may be due to a relatively high proportion of comments suggesting agreement with the statement on Survey 1.

Code	**Code description (allocated to comments in response to Question 2)**	**Survey 1**	**Survey 2**
YE	Working together can help people learn/solve problems more efficiently	4	9
ZC	Believes other people can help you understand	6	2
ZI	Believes working together helps you to engage with other methods/ideas	1	0
ZM	Believes working together helps you complete MORE work (more quickly)	3	4
Total for all above codes classified as 'positive'		**14**	**15**
ZG	Expresses desirability of working with others but with no justification	1	1
Total for all above codes classified as ambiguous ('positive' or 'negative')		**1**	**1**
ZA	Believes other people can distract you from learning	2	2
ZB	Believes other people can do the work for you and stop you learning	0	1
ZH	Expresses preference for working independently (individually)	1	0
ZK	Believes you can pick up misconceptions/misunderstanding from others	1	0
Total for all above codes classified as 'negative'		**4**	**3**

X	Inconclusive from comment (or question misunderstood)	0	0
	No comment made	1	1

Many of the comments for Question 4 from students in Aidan's class suggest they interpreted doing 'more in maths' as completing more work in a shorter period of time or with less effort, rather than achieving more through greater understanding, as the following comments illustrate (although Student 22's comment does hint at trying harder problems):

	Survey 1 Comment (Question 4)	**Code**	**Survey 2 comment (Question 4)**	**Code**
Student 8	*Because you can help each other if you don't know the answer.*	ZC (pos)	*When you do maths with other people it's easier.*	YE (pos)
Student 11	*You can do it quicker when you work together.*	ZM (pos)	*It will be faster.*	ZM (pos)
Student 22	*Because then you work quicker at it.*	ZM (pos)	*You can do more sheets and 'go' challenges.*	ZM (pos)

3.2.2. Comparison of survey 1 and 2 responses to Question 5 in Emma's class

There were 26 students in Emma's class who completed both surveys 1 and 2.

Question 5: Students were asked to explain the extent to which they agreed with the statement: *Maths can be used to mislead people.*

Of these 26 students, only 7 made an appropriate comment in response to Question 5 on Survey 1, although there were 13 appropriate comments on Survey 2 (see table below). However, none of these comments (on Survey 1 or Survey 2) was coded as 'positive', suggesting the increase in appropriate comments could not be attributed to increasing levels of SMA.

Code	**Code description (allocated to comments in response to Question 5)**	**Survey 1**	**Survey 2**
Total for all above codes classified as 'positive'		**0**	**0**
N	Argues maths can only be used in beneficial ways	5	2
Total for all above codes classified as ambiguous ('positive' or 'negative')		**5**	**2**
P	Claims maths is about right and wrong answers	0	1
Q	Claims maths can be confusing (not necessarily deliberate)	0	15
R	Making errors seen as a bad thing	0	1
S	Sees maths as something that can't be used to argue	1	0
V	People can't be misled as they can check the answers themselves	1	0
Total for all above codes classified as 'negative'		**2**	**17**
X	Inconclusive from comment (or question misunderstood)	1	5
	No comment made	18	2

Most of the comments on Survey 1 (all linked with a low ranking of the statement of 1 or 2) indicated students struggled to perceive mathematics as anything other than beneficial (see comments from Students 19, 30 below). Most of the comments on Survey 2 appeared to suggest a growing appreciation that mathematics could be 'confusing' but did not appear to link this confusion to lack of understanding of real-life issues (see comments from all 4 students below).

	Survey 1 Comment (Question 5)	**Code**	**Survey 2 comment (Question 5)**	**Code**
Student 6	[no comment made]		Because they might think the wrong answer.	Q (neg)
Student 12	[no comment made]		*Sometimes it's quite confusing.*	Q (neg)

Student 19	*Maths helps people.*	N (amb)	*It is really hard sometimes.*	Q (neg)
Student 30	*Does not make you rude - it helps with learning.*	N (amb)	Some people might not understand.	Q (neg)

A similar pattern of comments was observed for the comments in response to Question 5 from students in Aidan's class, with the exception of 4 students who appeared to develop an appreciation of how maths could be used to deliberately mislead people (coded as U).

Hence the statement does not appear to be appropriate for assessing component 1 of SMA. It may be that students were beginning to appreciate more the links between mathematics and real-life issues, and hence they were beginning to see the subject as less straightforward and more complex. However, this did not come through in the comments. In light of this analysis, the following alternative statement might be more appropriate for assessing component 1 of SMA in future:

You need maths to fully understand real-life issues.

4. Thematic analysis of research group meetings and interviews

The data collected included the audio-recordings of the evaluations of research lessons during Research Team Meetings 3 and 5 and audio-recordings of the interviews conducted with teacher researchers. The audio-recordings were transcribed and fully anonymised, with pseudonyms being used for teacher researchers and any third parties throughout the data analysis. Thematic analyses of these transcripts were carried out using a combination of deductive coding (derived from the theoretical background) and inductive coding (derived from a reading of the data). NVivo software was used to code the data and to facilitate the thematic analyses. A summary of findings can be found in section 5. More detailed findings (and supporting evidence) from the thematic analysis of the research group meetings and interviews are included in section 4.3 in this report.

The thematic analysis was based on Braun and Clarke's (2022) six phases:

1. Familiarisation with the data (through transcribing, reading and re-reading the data)
2. Coding (using a combination of deductive coding and inductive coding)
3. Generating initial themes (examining codes to identify potential themes, i.e. significant and broad patterns of meaning that emerge, and collating relevant data for each potential theme)
4. Developing and reviewing themes (review potential themes and collated data against research questions, split/combine/discard as necessary, and develop into themes underpinned by central concept/idea)
5. Refining, defining and naming themes (analysing, working out scope and focus and naming each theme)
6. Writing up (weaving together themes in analytic narrative in relation to research literature)

An initial coding scheme was generated from the theoretical background (see section 4.1). Two of the lead researchers (Pete and Caroline) then met and discussed how to apply this coding scheme to the data from one of the meeting transcripts and one of the interview transcripts. Through conducting this coding exercise, additional codes were added, and existing codes amended, to take account of data that could not be adequately coded with the initial codes. A coding log was kept as a record of these decisions taken jointly by Pete and Caroline (see section 4.2). The final coding scheme was then used to carry out the thematic analysis on the remaining research group meetings and interviews, which were shared out between Pete and Caroline. The joint coding exercise enabled Pete and Caroline to develop a shared understanding of how the codes should be applied.

Pete and Caroline then independently used Nvivo software to generate initial themes, by selecting and re-reading the text (from across all meetings and interviews) to which each code had been applied, identifying broad patterns of meaning, and using the looking for similarities, differences and connections with other codes. The initial themes were then developed and reviewed by comparing and discussing these initial themes. Further discussions led to the refining, defining and naming of themes and these final themes are reported in section 4.3 below. The report will be used as a basis for writing up the findings in the submission of papers to academic/professional conferences and journals.

4.1. Coding scheme for research group meetings and interviews

The final coding scheme is shown in the table below (*with the codes that were added or amended shown in red italics*). The coding scheme is in two parts: Part 1 (T) focuses on teacher agency and self-efficacy (relating to research aims 1 and 2); Part 2 (S) focuses on impact on students (relating to research aim 3).

Coding Scheme Part 1 (T): Teacher agency/self-efficacy	
Code	**Description**
T1: Developing thinking	
T1a	Confidence in own maths subject knowledge
T1b	Beginning to see maths in wider contexts
T1c	Changing views/epistemology of maths
T1d	*Recognising structural issues relating to inequality*
T2: Developing practice	
T2a	Promoting inclusion/access to activities
T2b	Creating safe spaces for learning
T2c	Innovating/taking risks in teaching maths
T2d	Providing authentic/meaningful contexts for maths
T3: Constraints	
T3a	Limited time for planning
T3b	Time allocated for curriculum subjects
T3c	Following a commercial maths scheme
T3d	High stakes assessments (SATs)
T3e	*Belief younger students can't engage with SJ issues*
T4: Opportunities	
T4a	Working collaboratively with colleagues from same school
T4b	Working with colleagues from another school
T4c	Possibility of doing cross curricular activities
T4d	Support provided from SLT
T4e	*Being part of a research project*
T5: Teachers' appreciation of socio-mathematical agency	
T5a	*Teachers appreciate links/applications between maths and social justice issues*
T5b	*Teachers appreciate power of maths to support argument for change*
T5c	*Teachers appreciate value of working together to solve maths problems*

Coding Scheme Part 2 (S): Impact on students	
Code	**Description**
S1: Students' socio-mathematical agency	
S1a	Appreciate links/applications between maths and social justice issues
S1b	Appreciate power of maths to support argument for change
S1c	Appreciate value of working together to solve maths problems
S2: Other mathematical competencies	
S2a	Communicating mathematically
S2b	Developing inquiry/investigational skills
S2c	Tackling real world problems involving maths
S2d	*Taking control over own learning (mathematical agency)*
S3: Active participation	
S3a	Motivated and engaged by contexts
S3b	Being able to extract meaning from maths
S3c	*Affective domain relating to students and maths*

4.2. Coding Log

The following coding log explains the decisions taken by Pete and Caroline in adding new codes and amending the initial codes through the joint coding exercise referred to above.

Date	Change to coding	Notes to explain change
03/08/22	Pete and Caroline discuss and agree initial coding scheme.	Based on underlying theory relating to teacher agency and efficacy, and students' socio-mathematical agency.
03/08/22	Initial coding scheme applied to transcript of Meeting 3	
03/08/22	Added new code T3e: '*Belief younger students can't engage in SJ issues*'	In response to transcript of Meeting 3 (first sentence in row #62): "*So, in my class we … it was a little bit difficult initially, I think, with Year 1's.*" (constraint not recognised in initial coding scheme)
03/08/22	Added new section with new codes T5a, T5b, T5c relating to '*Teachers' appreciation of socio-mathematical agency*'	In response to transcript of Meeting 3 (row #70): "*I just think you … an opportunity, you might go … a direction you might go in is … there seems to be an opportunity for some proportional thinking here.*" (teachers' appreciation of SMA not catered for in initial coding scheme)
04/08/22	Initial coding scheme applied to transcript of Interview 1 with Kate	
04/08/22	Original numbering system changed.	Makes it easier to refer to codes, e.g. 1.3.2 becomes T3b.
04/08/22	T4e changed from '*Being part of project*' to '*Being part of a research project*'	In response to transcript of Interview 1 (second part of row #4): "*I'm just interested in in all aspects and that sort of thing, so actually anything that involves research is of interest.*" (interest in research in general not recognised in initial coding scheme)
04/08/22	Added new code T1d: '*Recognising structural issues relating to inequality*'	In response to transcript of Interview 1 (including second part of row #4): "*YYYY will tell you he can't do maths and actually he's been told this*" (recognised distinction between equity and inclusion – T2a not adequate to capture this on its own).
04/08/22	Added new code S3c: '*Affective domain relating to students and maths*'	In response to transcript of Interview 1 (row #34): "I*f you if you go into my classroom and say ' oh maths time', sometimes you'll get 'uhhhh'.*" (range of students' feelings and emotions not recognised in initial coding scheme).
04/08/22	Added new code S2d: '*Taking control over own learning (mathematical agency)*'	In response to transcript of Interview 1 (including rows #68 and #70): "*Student agency, so the ability for children to sort of set goals, reflect and then kind of act to effect change.*" … "*No, they're not given an opportunity to do that*" (mathematical agency not recognised in initial coding scheme).

4.3. Findings from thematic analysis of research group meetings and interviews

Three themes were identified from the thematic analysis of the research group meetings and interviews with teacher researchers (TRs). For each theme, subthemes were identified as detailed in the table below:

Theme	Subthemes
1. Teachers' developing views of mathematics	• Teachers' varying relationships with mathematics • Teachers' development of a broader view of maths within the curriculum • Teachers' recognition of the legitimacy of social justice issues in maths learning • Teachers' appreciation that young children can engage with maths and social justice (see sections 4.3.1 to 4.3.4 below)
2. Teachers' developing agency and efficacy	• Teachers beginning to challenge students' beliefs about maths • Teachers rethinking strategies and approaches to teaching maths • Teachers beginning to navigate constraints of curriculum • Teachers appreciating the importance of collaboration and peer support • (see sections 4.3.5 to 4.3.8 below)
3. Students' developing socio-mathematical agency	• Students taking greater control over their own learning • Students' increasing appreciation of how mathematics is relevant and applicable to real life • Students growing appreciation of how maths can be used to argue for change • Students increasingly able to work collaboratively to solve problems • (see sections 4.3.9 to 4.3.12 below)

The subthemes are described in detail below, accompanied by supporting evidence, and a summary of each of the three themes can be found in section 5.3.

Theme 1: Teachers' developing views of mathematics

4.3.1. Teachers' varying relationships with mathematics

Many of the TRs described having negative attitudes towards maths themselves based on their own traditional experiences of learning the subject at school. Whilst recognising the importance of maths, Kate felt anxiety towards the subject:

- We can bring maths into absolutely everything. And I am a person who is happy to admit I'm relatively scared of maths. If you ask me, I'll tell you "I'm rubbish at maths". (Kate, Int2, #17)

For Emma, Rose and Aidan, their own dislike of school maths seems to have inspired them to want to provide their own students with a more positive experience:

- When I did maths at school, I didn't enjoy it, and I felt like it was you're either doing the right thing or you're doing the wrong thing. So, I kind of want to see is there any way of making it more inclusive that all children when they do maths it's, yes, there's a right and wrong, but there's also different steps in between. … That's what interested me the most. (Emma, Int1, #2)
- As someone who didn't like maths at school, I think any opportunity to, kind of, make maths more meaningful, and accessible to all, is going to have a benefit on the classroom. (Rose, Int1, #49)
- Coming away from the important idea of, which I find particularly in this country, is you know that it's all results based … rote learning and rote understanding, well, that's the most important thing. When, actually, we really should be teaching the children to think a lot more and talk. (Aidan, Int2, #10)
- When I was in school, it was completely rote learning and 'on the surface', and you didn't have these opportunities. And, probably, why I look back and think about so many things that "Why didn't they teach us that in school?". (Aidan, Int2, #21)

In contrast, Layla appeared to have a pre-existing positive relationship with maths:

- I'm passionate about maths … and anything I feel that can promote it in any way is great. (Layla, Int1, #4)

4.3.2. Teachers' development of a broader view of maths within the curriculum

The TRs expressed a wish to go beyond the constraints of the current maths scheme of work and to provide a richer and fuller maths curriculum:

- Particularly maths mastery sometimes feels that way [narrow], and that we've got a lot to get through … And, actually, it's quite nice to step back from it and think about … how can we add value and provide, like, a richer curriculum for the children? (David, Int1, #88)
- As a professional I would like to echo what David said there as well, and just … a richer and fuller curriculum. (Aidan, Int1, #93)
- Coming away from the important the idea of … it's all results based … rote learning and rote understanding, well, that's the most important thing. When, actually, we really should be teaching the children to think a lot more and talk. (Aidan, Int2, #10)

The TRS expressed a desire to introduce more discussion and debate into maths lessons:

- I think in schools, we get very fixated on, you know, having to write something in every lesson … you can achieve so much more sometimes just by having a really good debate or acting out a scene or getting outside of the classroom and doing something with them that's practical as well. (David, Int2, #94)
- And often we get hung up on, well, you know: "We need to complete these particular maths lessons" … You've got your maths element here, but you could have introduced a persuasive writing type of text, where they actually do some writing on why their particular idea … is the better one and why someone should vote on it. (Aidan, Meet5, #87)
- I think we sometimes don't give them enough opportunities to explain "This maths can be used in your own life" or "This can be used here". So, I think it's just making more reference across the board. (Emma, Int2, #16)

The TRs developed a greater appreciation of where maths can be used and applied in other subject areas:

- … it's helped to broaden my horizons in terms of thinking about where there are opportunities to bring it into, not only maths, but to other subjects. (David, Int2, #89)
- And it's also got me thinking of how I can, kind of, open up these conversations within different lessons, and how maths skills can be used within other areas … trying to look more for the links. And I think it's just made me more aware of the fact that maths can be used in different ways. (Rose, Int2, #8)
- I think there's a lot of areas we can use … obviously, PSHE … with geography … I probably have to put a bit more thought into what we can do … even in English, if you're talking about data and that sort of thing. … I think there's so many different subjects that you can use it. (Kate, Int2, #51)

The TRs developed a greater appreciation of how maths can be used and applied in tackling cross-curriculum topics:

- We're even looking at different food groups, as well, and where food comes from, which you know there's certainly some nice links there. (David, Int1, #33)
- So, what myself and [David] did, we did the same task. So, the learning intention for the task was, with it being British science week last week, we decided to do something, kind of, around that, but with a maths element to it. (Aidan, Meet3, #84)

The TRs demonstrated an appreciation of the need to make maths more meaningful and purposeful by relating it to students' everyday real-life experiences:

- I think it's, kind of, made me think "Well, how can I draw on examples in maths lessons from the real world, how can I get children to think about maths differently, and how can I get them to use maths to show a different perspective?" (Rose, Int2, #25)
- I would love the students in my classroom to feel like … they know why maths is important. Again, it's not just because "We have to do because my teacher tells me to". (Rose, Int1, #52)
- I think it's more, just, giving children opportunity to think … giving them a way to understand "This maths can be used in real life scenarios". Just making more links back to things they would understand. (Emma, Int2, #16)

The TRs articulated how they had begun to give greater attention towards drawing links between maths and real-life contexts and devoted more time towards this in their teaching:

- Well, I think … the way that I introduce any new topics … is we have a good discussion about why we are learning this. So, it's not a case of "We're going to do fractions today", it's a case of "Why is it important that we know how to do fractions?" or whatever the specific learning intention might be. So, I think that always relates to the children and their world, and their future world. … And that's a regular thing through the lessons. (Layla, Int1, #9)
- I always thought that was something I had done in all my maths lessons anyway. I was trying to make it, kind of, real life if possible, using things that are tangible, relating it to things that are going on in the world and stuff. But I guess, after the first interview, I was a little bit taken back by "Oh well, maybe they haven't kind of grasped this" … I put a lot more emphasis in, not just in the kind of standalone lessons, but in my lessons in general, to make a point of maybe stop and take a moment to have a bit of a longer discussion, rather than having that like brief introduction of how this is relevant to the world. (Aidan, Int2, #3)
- And I think there's not always enough time to teach, in depth, everything. … but the things that you can make reference or give examples or scenarios, I try to involve that a bit more. (Emma, Int2, #28)

The TRs described how making maths more meaningful had a positive impact on students' engagement:

- And I think that idea of, it's something they know about … They just were thinking a lot more into it than if it was something that they just didn't really know about. (Emma, Int2, #4)
- I think that's how I overcame the challenge of the first one, was by really thinking about the second one, and making sure it follows a pattern and it's relatable to the children. As soon as I made it relatable, and said it was a street down the road, they were more into it. (Rose, Int2, #30)

4.4.3. Teachers' recognition of the legitimacy of social justice issues in maths learning

The TRs described how they hadn't necessarily made a strong link between maths and social justice in the past but were intrigued at the prospect of doing so through the project:

- I couldn't see remotely how you would link that [social justice] to maths, so it's really interesting then so to find out how you're going to link it to maths. (Kate, Int1, #6)
- I think it's [social justice] one of those things that perhaps you would more easily look at in history and PSHE. (Kate, Int1, #60)
- When I first came into this project, I was thinking "I wonder how we're going to… fit this in". And, if I'm being honest, this really has made me think a lot more about, you know, the importance of these topics and how we can integrate these into, you know, the lessons that we are teaching. (Aidan, Int2, #38)

- Social justice is something that is in the news a lot and something that I think we can connect to a number of different subjects. And I guess I hadn't really considered maths necessarily as one of those, or one of the ones that is the most obvious. But I'm really interested to see how we can, kind of, bring the two together and do it in a way that's meaningful. (David, Int1, #19)
- … when we first spoke about it … maths and social justice are things I wouldn't normally put together. … I studied politics at uni[versity] and did a Master's in politics … social justice is quite a big personal value for me. And maths is an area where I did not like it at school. So, it's two completely different … subject areas. And I just was really interested to see how they would work together in a classroom. (Rose, Int1, #2)
- So, the only, kind of, element where I bring in real world to math lessons is when I say … "you might need to read a bus timetable". … I'd say, at the moment, I don't bring social justice into it. Which is why I was so interested in [the project]. (Rose, Int1, #11)
- And, again, like [Rose] … even though I'm very engrossed in maths, I've never really thought of it from that point of view. I've very much been a bit blinkered in this … looking at maths anxiety, or trying to promote, you know, more a growth mindset in maths, and that kind of thing. So, I just thought "Oh, that would be … this is quite interesting". And again, looking at opportunities, how that can promote growth mindset within the subject as well. So that's my interest. (Layla, Int1, #4)

Through participating in the project, TRs appeared to develop a stronger commitment towards tackling social justice issues through teaching mathematics:

- I think it's an awareness. I had no idea that you could tie these two topics together. And it was, kind of, looking at the world and thinking "Well, how can I get some of these issues within these lessons?" … understanding how maths can be used in a different way and, kind of, seeing that in practice, has been quite a big impact on me and my teaching. (Rose, Int2, #21-22)
- … and it may be not just going for a maths perspective but try and encompass all areas of the curriculum … you have to want to do this, you have to try and then search for the links. But I think they are there, just takes a bit of searching. (Rose, Meet5, #112)
- There's links to [social justice] in terms of, again, thinking about how we're eating … eating the right things and exercising and doing good things for our body. And I think there's some opportunities potentially for social justice there where you make comparisons with other countries that maybe aren't as fortunate and don't have the same freedoms that we have. (David, Int2, #50)

Aidan appeared to be particularly motivated by the challenge of introducing social justice issues into his maths lessons, from his own professional perspective and out of a desire to tackle challenges facing society:

- I just thought it would be very interesting, as a newly incoming [maths] lead, to see how we might implement social justice in our maths teaching and within the math curriculum, or across all subjects. Social justice is a particular topic that interests me, coming from a very diverse background myself and living in an area of a lot of cultural diversity as well. (Aidan, Int1, #17)
- It's a great opportunity to bring in, like, issues that are going on in the world today that, you know, they are ultimately going to be responsible for in the future … getting the next generation ready. (Aidan, Int2, #10)
- One thing I thought might be interesting would be to … purposely miscount, or miscalculate, the result. And hopefully, you would expect quite a lot of the children to notice the mistake, and then realize the importance of the mathematics in achieving an accurate result, and in achieving this fairness as well. (Aidan, Meet5, #91)

The TRs demonstrated an appreciation that some people might question the legitimacy of tackling social justice issues in maths lessons and that it needs to be done sensitively:

- I think some people might think "social justice and maths, is this what we should be teaching?" … some people might be a bit resistant to it … anything, sort of, diversity related I think people can be quite sensitive. (Kate, Int1, #150-152)
- Then you realize … there's always opportunities there to bring in interesting discussion and not shy away from it. I think, as a teacher, particularly with seven-year-olds, there's always like "Oh, should we be going near that topic or subject?" But, actually, they do know more than you realize and, as long as you're giving everything in a very balanced opinion and explaining that there's two sides to an argument, then I think we're doing the right thing. (David, Int2, #91)

The TRs highlighted the need for real-life applications to be genuine and for links between maths and social justice to be strong:

- … we follow a scheme within the school … the images they use are all real-life images like counting objects, … you know four sets of, you know, three cakes … Even though they're seeing that on a daily basis, … they will see [images] as a maths lesson and "I'm just learning how to count numbers". (Aidan, Int2, #5)
- … there does need to be a very clear link and purpose to social justice, and it not be tenuous. And that can sometimes, obviously, be the case. And we talked about that as one of the big challenges when we started the project. (David, Meet5, #114)
- And it might feel I'm just being a bit, maybe, tokenistic with trying to fit a social justice issue in, which I feel would undervalue the whole point of doing this. (Rose, Int1, #37)

4.3.4. Teachers' appreciation that young children can engage with maths and social justice

The TRs described the perceived challenges in making complex social justice issues accessible to students:

- And I think, for myself and [Kate], as Year 1 teachers, we were like "How do we simplify that, still get the same ideas across, but equally make it make sense to the children?" … we found that slightly challenging to simplify it without losing the whole point of doing this. (Emma, Int2, #32)
- And I suppose, for small people … there are some topics you wouldn't necessarily go for, whereas if you're talking about years five and six, you can look a lot more … I think it can be a little more tricky with year one. (Kate, Int1, #135-137)
- Obviously, there's limits to talk and to the conversation, and what you'll get out of them … we had that lesson on democracy … they understand the concept of voting, which is great, and they've started to really understand what that means and how democracy works on a very basic level … With the younger children, my sense is that you need a very clear … keep them focused on what they're doing … make sure they have a very clear idea of what you're trying to do and to achieve. Whereas, I think you might have a little bit more flexibility with older children … have those discussions that may be move just slightly away from the topic you're talking about into an area of social justice, but then bring it back again, without confusing them. (David, Int2, #28-30)

Emma appeared to remain more sceptical than other TRS about younger children being able to engage fully with social justice issues, particularly those not relating directly to their own experiences:

- So, I think, looking at social justice and fairness with such young children, it has to be based, for them, around what, kind of, they are interested in, more than general topics. (Emma, Meet5, #20)
- … there was one conversation [with colleagues], one day, about: "… are the children too young in Year 1 to know about what's going on in the world?" … I think it does spark a conversation. (Emma, Int2, #46)
- But, sometimes, it could be over complicating the concept by giving the purpose to it. Whereas some maths … it might be easier just to teach them the knowledge. And then, maybe at an older

age, looking at more purpose across the board, or things that they feel like it has a purpose in their day-to-day. (Emma, Int2, #30)

However, Emma appeared to recognise that her feelings may not be fully justified by her experiences:

- I think it's got me thinking about, even though they're five and six-year-olds, they have opinions, they have quite good ideas. And, like, getting them involved in classroom decisions, I think, is very beneficial, even from that age. And I think, beforehand I, maybe, dismissed slightly, of them being so young, that maybe they won't understand. (Emma, Int2, #8)

The other TRs appeared to develop a greater appreciation of the extent to which younger children can engage with complex social justice issues:

- So, it's opened my eyes, I guess, a bit more to … not kind of pigeonhole, you know, seven-year-olds into "they won't understand that or that, this isn't relatable to them at their age". Actually, to be more ambitious, if you like, to think actually they can do more than you realize, you just need to give them the right framework to be able to do it. (David, Int2, #35)
- "Should we be doing that in maths, should we be doing that in year one? Is it too young? Maybe they shouldn't be learning these things" – but, you know, that's something, by bringing this in from early years, hopefully, will change those perceptions. (Kate, Int1, #156-158)
- I've been surprised at how children can deal with quite, like, complex issues. I knew they could, but just some of the suggestions have really surprised me … it's made me think "Well, how can I make this work with younger children?" (Rose, Int2, #8-10)
- Because there's some heavy issues there … it didn't faze them at all to, obviously, discuss them … apply the activity to them. So, yeah, I'm impressed with their maturity … slightly surprised and impressed with their maturity. (Layla, Meet5, #71)

The TRs articulated the importance of children engaging with social justice issues from an early age:

- … children have opinions … they're not like adults, they're quite blunt and they'll just say what they're thinking … that might be an idea that they've just overheard from their parents or that are around them, but … their answers are a good opportunity then to have, you know, informed conversations … (Aidan, Int2, #26)
- And if it was, kind of, built in from early on, I think it would challenge those attitudes … So, start from a younger age and, like, build it in really slow like drip feed it in, I think, that would be the best way. (Rose, Int2, #34)
- I think if you've got everything in place from early years … through primary school, through school in general … it's no point, sort of, when you get to your teenage years starting to discuss things … (Kate, Int1, #17-19)

The TRs also articulated the importance of younger children engaging with social justice issues in learning maths:

- Starting them at a very young age, and if this is implemented through all of all year groups, by the time they get the secondary school, they've developed that understanding, a way of questioning and, obviously, having the mathematical aspect of how to how to work, things out and understand how actually this might be an inequality and injustice. (Aidan, Int1, #94)
- I think, going forward, as they get older, if we continue going with this … children will then be able to look at data in different ways … when they see a poll, as teenagers, … they can realise that actually you can manipulate figures, for example. And I think … across the board, from 'tinies' up to, you know, the end of your school life, we can use this sort of thing to build. So, yes, it's maths, but actually it's life skills for the children as well. (Kate, Int2, #15)

I think it's really important for children … that they understand these issues, because … what I found out is they're not as innocent as we think. They actually, like, absorb a lot of information. (Rose, Meet5, #112)

Theme 2: Teachers' developing agency and efficacy

4.3.5. Teachers beginning to challenge students' beliefs about maths

The TRs described how some students lack confidence in maths and don't identify themselves as maths learners (even those that are relatively high attaining):

- [Child 1 in class] will tell you she can't do maths, [child 2 in class] will tell you he can't do maths and actually he's been told his … his mental maths is apparently off the chart, but he'll still tell you he can't do maths. (Kate, Int1, #32)
- … if you've looked at assessment in my class, probably in the, sort of, 'top tier', whatever you want to call it … they wouldn't necessarily view themselves as strong mathematicians or even as mathematicians. (Kate, Int1, #40-42)
- And just be mindful as well, particularly in years two and three, we've still got children that really struggle with word problems … might actually be quite good at maths, but get really frustrated very quickly when you put written words in front of them instead of numbers. And you can almost see, kind of, the "Why can't I do this? … I'm good at maths, but I can't access this". (David, Int1, #83)

The TRs showed a willingness to challenge students' mindsets by emphasising that mistakes were part of the learning process and not to be feared:

- … a big part of it is having that growth mindset as well … It's to not be afraid of making mistakes and to make sure that they're really clear that actually mistakes are how they learn … There's still children in my class that get upset if they can't do something or they make mistakes … (David, Int1, #69)
- … and for teaching that mindset, of you knowing: "how can I achieve my goal? Yes, I will make mistakes, but I have these resources to help me achieve the goal that I have set or the task that's in front of me." (Aidan, Int1, #73)

The TRs were beginning to challenge students' views about maths by showing them how learning maths can be more meaningful and purposeful:

- … quite a lot of the children had that assumption, you know, that maths was just for answering questions in school. And I've tried to reiterate in every lesson … where the benefits of this type of learning will help in the real world, and just almost overemphasise them so that they don't say that again. (Aidan, Meet3, #8)
- I think in year one, maths is very much … it's in the classroom, it's in the maths lesson. They're quite specific about that. And they were starting to see, actually, how we can use maths, how we can use numbers in different ways. (Kate, Meet3, #63)

The TRs described how students began to adopt a more positive attitude to maths when it was presented in a way that made more sense to them:

- But, I think, by presenting maths in a different way, I've had less of a "I don't want to do this, this is boring" reaction, and then seeing "actually, this is maths used in a different context". (Rose, Int2, #30)
- Because they found something that made sense to them, we've got more out of the children in comparison to maths scenarios that have no sense to them. (Emma, Meet5, #14)
- And they could see how maths then translates into their … real lives. And they could see, yes, they are mathematicians, they just didn't realize it. (Kate, Meet5, #17)

Kate described how students' confidence in maths was boosted as they experienced success in tackling problems in which they could see how maths could be applied to meaningful situations:

- And then, for your children, potentially, who think … "I'm rubbish at maths", actually, they can see that they're not. And they're using what they've learned in maths in a subject that, potentially, they might be more interested in. So, it can then boost children's confidence … and reframe how they view themselves as 'alone with maths'. (Kate, Int2, #53)
- I've got a couple of children … who might say … "I can't do maths", but actually, you know, when they're enjoying this sort of physical stuff, and we're saying to them "So this is partly what you've learned in maths", they then recognise that they can do it. (Kate, Int2, #57)

The TRs reported how some students who exhibited anxiety towards maths, whilst not overcoming their negative attitudes, did appear to be more positive towards using maths in different contexts:

- I think another challenge has been the children's attitude towards maths. Again, speaking about those children who have those maths anxieties, who have those quite negative views, I don't think I've fully been able to overcome them. But, I think, by presenting maths in a different way, I've had less of a "I don't want to do this, this is boring" reaction, and then seeing "actually, this is maths used in a different context". (Rose, Int2, #30)
- You have got children in Year 1 who still think they can't do it, and will tell you that this child and this child are really good at maths, and "I'm not". So, I think, potentially, it can help, very gently, to reframe their thinking. It's not going to change the world, but I think it might have an impact. (Kate, Int2, #59)
- And the children just saw maths as a maths lesson, whereas in comparison to now, when we've maybe had more of those conversations that, you know, there's scope for so much more. (Aidan, Int2, #38)

However, Rose also reported how some students were still put off when they realised the project activities involved maths:

- However, those that still don't have that positive attitude towards maths, as soon as they've realized that it's, kind of, got maths in it … I've lost them a little bit. But I do have some children have quite negative views towards it, which I've tried to overcome. (Rose, Int2, #4)
- The ones who find maths easy were happy to do it. It was just another way of, kind of, organizing their thoughts and problem solving. But I did notice there was a slight level of disengagement with children that were like: "Oh, it's a maths lesson, I can't really be bothered to do it anymore." (Rose, Meet5, #66)

4.3.6. Teachers rethinking strategies and approaches to teaching maths

The TRs showed an interest in their own professional development and welcomed the opportunity to reflect on their teaching practice:

- As a teacher, it's good to have an opportunity to explore new ideas. … I'm very early on in my career … this is my third year of teaching … so, I am very keen to, kind of, see what opportunities being involved in something like this will bring in terms of my future research or future ideas that I want to try out. (Rose, Int1, #50)
- But it has been rewarding, I think we've all seen, and got some real benefit from it. It just needs to be seen as how it can be integrated and fitted in potentially with the maths program that you've got. (David, Meet5, #114)

There was consensus amongst TRs that the project has had a positive impact on their thinking and practice:

- I think it's got me to think how can I include collaboration a little bit more in the lessons and, kind of, draw out the problem solving aspect of maths … We have a very set way of teaching maths. But it's definitely in my approach to … the delivery of the lessons and the way I ask the students, and the way we interact with the maths on the board, that has perhaps changed. (Rose, Int2, #24-27)
- So, yes, it's definitely … improved my own maths teaching. (Aidan, Int2, #9)
- So, I think this is just given me a new avenue, that this has gave me a more focused avenue on that, sort of, line of questioning and discussion within the class. But it certainly does … it fitted with my style of teaching. (Layla, Int2, #10)

It was already common practice amongst TRs to adapt their teaching to meet the needs of all students by providing tasks at three different levels of difficulty (often with the higher attaining students being given problems that required higher-order thinking skills). However, some of the TRs were beginning to question some of the assumptions on which this approach was based:

- And maths is definitely one of those subjects where you kind of make assumptions that some people will get something, and some people might struggle. And then sometimes it completely surprises you … you realize a child, who you thought would just fly with this task, is struggling … one that you thought would struggle is doing really well. (David, Int1, #56)
- I don't know if the tasks that I've generated catered for everyone's, kind of, level. I think it was really hard to find an activity that … stretched everyone … whilst making sure that those who are at 'greater depth' are pushed enough. (Rose, Int2, #24)

The TRs were also willing to reflect critically on other aspects of their practice and began to consider different approaches to teaching maths that they saw as being more inclusive. For instance, small group discussions were seen as providing opportunities for quieter students to participate more:

- In a small group in a quieter environment, particularly for our children who … they don't need help all the time and they're not one of the 'high flyers' … I hate this phrase, but 'invisible children' … they just don't want to talk … if they're in a small group they can get involved in these investigations … it allows them to think and get their voice heard and say what they want to say. (Kate, Int1, #192-197)
- We did mixed ability groups, because it was a practical task. And it was quite nice to see the children who might be classed as lower attainers were really able to get involved and come to the fore as much as the children who are often seen as the higher attainers. (Kate, Meet5, #13)
- They were able to select a spokesperson to speak on behalf of the group. That actually included one child who was happy to speak, who isn't so confident in maths, and does find things challenging. (Rose, Meet5, #61)

The TRs reported that the problem-solving approaches adopted in relating maths to real-life contexts also enabled wider participation amongst students:

- It's made me look at my planning a little bit differently and see what we can bring into it … seeing, actually, how more practical aspects benefit different children, it's helped to sort of identify that and bring it into the teaching. (Kate, Int2, #33)
- I'm a big pusher of girls being involved in STEM, so I would love for more girls to feel like "Look, I can do this, I can … maths is actually interesting, it's an issue that I want to get into". And they see that maths is just more than just calculating things, it actually has a wider impact. (Rose, Int1, #52)
- … when we gave some of the children who aren't keen on maths, or children who aren't keen on giving opinions, … more physical tasks ..., they were more confident to express an opinion or ideas in that sort of environment. (Emma, Meet5, #26)

4.3.7. Teachers beginning to navigate constraints of curriculum

The TRs described how both schools had adopted a mastery-style scheme of work for maths. They reported that, whilst in theory these schemes encouraged students to go into more depth and apply maths to solve real life problems, in reality more time would be required to do this given the pressure on teachers to cover such an excessively large maths curriculum content:

- Certainly the scheme that we use … we've got quite a lot of flexibility with it … would use real life examples and always bring it back to that … But that's in maths (Layla, Int2, #46)
- … we do a maths mastery program which is just jam packed in terms of the amount that we have to get through. (David, Int1, #28)
- And I think constraints of the actual curriculum is probably the major one really. Like if you reduce the amount that children need to know at certain age groups, you can not only learn the maths in depth … but you could relate … the mathematical topics to real life scenarios. And without any change now, I think it's very difficult to … because you just don't have the time to have these conversations every day, as great as they are. (Aidan, Int2, #45-46)
- I think there are time constraints, in the curriculum … if we could have more time for them to complete investigations, based on talk tasks … the maths mastery framework gives you that opportunity, but time wise it doesn't work … (Kate, Int1, #81-83)
- I think, because you've only got a certain amount of time to teach maybe a subject idea or a concept, you don't get the time to, kind of, in depth, explain how this references them [real life scenarios] … And I think there's not always enough time to teach, in depth, everything. I think it's a 'pick and choose' sort of idea. (Emma, Int2, #18-28)

The TRs also reported on the challenge of getting through the extensive general primary school curriculum which restricted the time available for project work incorporating maths and social justice:

- I think, again, the main one [constraint] is time and … fitting it into the curriculum, the already overly ambitious curriculum, that we have in primary schools … that's definitely the biggest challenge. (Layla, Int2, #40)
- I think one of the biggest challenges … and I guarantee that every other person will say this … every teacher always says this … making sure there's adequate time for the lesson. (Rose, Int2, 29)
- It would be really nice for the curriculum, maybe, to lend itself to have these types of lessons more often. And often we get hung up on, well, you know: "We need to complete these particular maths lessons, these particular geography lessons". (Aidan, Meet5, #86-87)

The pressure to cover curriculum content was particularly acute in the lead-up to the SATS tests:

- In Year 6 … we're now in SATs mode, unfortunately, it's, kind of, it's changed. Almost, our focus now is very much on getting through the exam and giving them practice for the exams. (Layla, Int1, #22)
- And again, like [Rose], I mean, every year group is a busy place, but Year 6 is now crazy, like I said, with the ramp up to SATs. And the focus very much on that as well as, you know, everything else that we do in Year 6, with trips and church services and everything else. … So, it's about making sure that it fits in. (Layla, Int1, #43)

Despite the pressures of curriculum time, the TRs reported how they were able to incorporate new ideas based on identifying genuine links between maths and social justice:

- It's finding the right fit and being conscious that there's a big curriculum to fit in … I think, like, the democracy lesson that we did was fantastic, and that was almost like a standalone lesson. (David, Int2, #51)

- So, it's about making sure that it fits in … it's meaningful for the children as well, you know, as well as it fits in with what they're doing in their curriculum. (Layla, Int1, #43)
- It's trying to make it work and weave into your existing curriculum, but also so it's not tokenistic and you're just, kind of, throwing it in there, and make it meaningful. (Rose, Int2, #29)

The TRs also described how limited availability of time for planning made it difficult to develop new ideas and resources:

- It's quite a lot of work, obviously, to pull together separate lessons … like this. And so, just the realistic expectation of doing it regularly, and moving outside of whatever maths program that you're on, it's challenging. (David, Meet5, #114)
- But, I think it would have been nice to have more time to work on it together. But, you know, just the pressures of the job, sort of, … did make it a little bit tricky. (Kate, Meet3, 108)
- It's a one-word answer … 'time'. And I think, with everything going on, time has been, for us, an absolute premium at the moment. (Kate, Int2, #37)
- So, I think for me, it was more just trying to fit in the time to, actually, think about it with the other demands. (Rose, Meet3, #107)

At the same time TRs recognised the benefits of committing the time towards developing new approaches:

- I would say that you just need to make sure that they [teachers] can see there are opportunities to really exploit these issues in the curriculum. And I think it probably has to come from a bit of, like, drive and motivation. (Rose, Meet5, #112)
- So, again, it's just about having that time … But, you know, I think we've all seen that there's some good benefit of doing it. (David, Meet5, #115)

Despite the constraints that they faced, the TRs described how they were able to foster problem-solving approaches and deeper understanding in developing links between maths and social justice:

- What we had was we gave them the time to actually work through different … because, quite often, when they're working, they have to work quite quickly, whereas they just had time to play around with it, and sort of discuss it. (Kate, Meet5, #23)
- Because we do a 'mastery' approach … rather than solving 10 different problems, you're meant to find 10 different ways to solve one problem. I think it's got me to think: "How can I include collaboration a little bit more in the lessons? And, kind of, draw out the problem solving aspect of maths? And, kind of, the ways we can think about it?" … that kind of critical thinking for the 'greater depth' children has been impacted, I think, a lot in my maths lessons from being part of this project. (Rose, Int2, #24-25)

4.3.8. Teachers appreciating the importance of collaboration and peer support

The TRs appeared to recognise the potential benefits of being part of a collaborative research project and to appreciate the value of having the time to share ideas with colleagues:

- … anything that involves research, and just looking into things in more depth, and anything that will improve my practice is something I'm going to be interested in. (Kate, Int1, #11)
- … like I said at the start, from my personal perspective, it's just to understand the processes of a research project and how it's broken down and how it's approached, and then the end results. (Layla, Int1, #54)
- … being able to collaborate with other teachers. I think, generally, it's very rare it's not helpful to your own practice. So, I'm looking forward to, maybe, hopefully, establishing a bit of a network with other teachers to do with maths, and be beneficial for everyone involved. (Rose, Int1, #52)

- … always in our profession, you know, any sharing of best practice, sharing of similar challenges … we just don't have the time to do it enough … I think, as teachers, everybody would welcome any opportunity to do that. (Layla, Int1, #47)

The TRs described how sometimes, for logistical reasons, it was easier to work with a colleague from the same school:

- But I think for [Emma] and I, because we work very closely together, obviously it was easier for us. We know how each other works. We knew what we were doing. (Kate, Meet3, #108)
- [Aidan] and I did actually have a conversation … we're in the same school … just about what we were doing. I think, from that, we got a few ideas. So, we found it much easier to do it within our own schools, because you have those, kind of, informal catchups about it. (Kate, Meet3, #109)
- What was difficult was … being in different schools … I was ill one week, he was ill one week, and there was parents' evenings in the [East School] one week, and there was parents' evenings in our school an opposite week. So, we were both trying to get in contact with each other … collaborating across schools was quite tricky … maybe a little bit easier for myself and [Rose] to then link up, because of, maybe, a particular focus that we have within the school in that particular week. (Aidan, Meet3, #100-110)

However, the TRs who had the opportunity of collaborating with a colleague from another school described how this enabled them to broaden their own perspectives on practice:

- I think it's been really good to work with a fellow year two teacher, but from a different school. So, it's good to, kind of, broaden your horizons and meet new people and get new ideas. (David, Int2, #34)
- … when we brainstorm together, as well, you come up with much stronger ideas … when you're working with another individual, it … just expands, obviously, your range of thoughts and ideas and directions that you might go in. And hopefully, you know, you complement each other as well … I'm not sure it would have been as strong if I'd have been doing it on my own. (David, Meet5, #115)
- And the collaboration with other teachers … I've seen how beneficial it is. It's been interesting to do it across two schools, because you get different ideas, and you pick up on different techniques and strategies. (Rose, Int2, #22)

The TRs articulated how being part of a collaborative network of teachers and researchers had a positive impact on the development of their practice:

- Again, being part of the, kind of, teacher researcher network that this project has is really beneficial, because, obviously, we use different math schemes and we have different ideas. (Rose, Int1, #49)
- I think that that's been a real benefit … And I just think it improves everybody's practice across the board. It's giving you different ideas. We had such a mix of people bringing ideas to the table, you know, people who have, you know, come from different backgrounds recently into teaching. (Kate, Int2, #23)
- The collaboration, the meetings with other teachers. I liked it when we shared all ideas and we heard what other year groups were doing … seeing how they were approaching it, just helps. And being able to bounce off other people, as well as speaking with that yourself and the other researchers, just having like a sounding board, I think it's crucial … if you're trying to do something new, you just need to get a group of like-minded people, who will have different skill sets, to kind of work with each other, but also challenge and suggest new ideas. (Rose, Int2, #32)
- I think just having, sort of, a timeline helps, having that timeline and deadlines. If it was just a "Right, go and get on with this" at whatever time, … it would probably never become a priority. So,

I think just having those regular check-ins … working together as team, helped. And the structure of the program helped. (Layla, Int2, #36)

- It's been a really interesting experience … and, you know, I think we've all been on that that really good journey together, which has been great to see. (David, Int2, #69-70)
- … and this was a really interesting project that, you know, I got quite a lot out of, and I know the children did as well. (Aidan, Int2, 71)

The TRs described how there was some interest in the project shown from other colleagues, although this was limited:

- I think, from what I've found, that they're [colleagues] definitely interested to speak, like the geography lead, and the history lead … and see how we can incorporate a bit more maths … people ask: "How can you do it?" and then we tell them, and they seem interested. (Rose Int2, #38-39)
- Obviously, with Joel taking the lead on it, you know that there's, you know, a bit of interest in terms of other teachers and what we're up to, and, you know, what we discussed when we get together as a group. (David, Int2, #63)
- I think it's got the conversation going between those of us who have done the project. But I don't know how many of colleagues across the school are aware of what we're doing. (Kate, Int2, #61)
- There's another Year 6 class, so I've mentioned it. The Year 6 teacher was quite interested to hear about it. But, yeah, it's been, sort of, quite closed in that sense. It's not something that's been openly discussed in the school. (Layla, Int2, #48)

The TRs articulated the importance of support and leadership from senior teachers for embedding the ideas in practice across the school:

- But I guess it, like, we said in the last meeting, it has to come from a real push, top down, from the SLT. And a real motivation to see like the value in it. And I think teachers will buy into it then. (Rose, Int2, #39)
- I think it's difficult to come from individual teachers in classes, and I think it's something that needs to come from management, and be a whole school thing, and a whole school ethos, that's built in. (Aidan, Meet5, #109)
- I very much agree with [Aidan] … to get through the curriculum and the learning that, you know, we need to … in primary schools is, you know, very tricky indeed. So, it would need to be integrated, it would need to be part of the curriculum and therefore then dictate what you do in school. (Layla, Meet5, #111)

Theme 3: Students' developing socio-mathematical agency

4.3.9. Students taking greater control over their own learning

It was already common practice in maths lessons to allow students to select from a range of tasks with varying levels of difficulty/challenge, referred to as 'ready', 'steady', 'go' at West Primary School:

- So, the questions will be split up into a 'ready' and a 'steady' and a 'go'. And the children will be able to choose which level they start on … The student agency mainly comes from their choice of challenge and … being able to choose which maths puzzle they do, which one appeals to them the greatest, and choose their strategy. (Rose, Int1, #13)
- In maths, with the 'ready, steady, go' … it really empowers them to set their own goals and be in charge of, and have responsibility for, and what they're choosing to undertake in maths. (Aidan, Int1, #45)

Although there was an appreciation of the need to sometimes moderate students' choice of activities:

- Even when I'm handing out the sheets, there's a lot of "I want easy sheet, Mr YYYY" or "I want a simpler one". So, you have to make sure that those children that like to take the easy road, if you like, are still pushed. (David, Int1, #54)

There was also an appreciation that encouraging students to tackle meaningful activities and develop a greater sense of ownership would lead to higher levels of engagement:

- I think that's quite important that again when we do these types of activities, it's not just a tick box exercise, they actually feel empowered and they feel like it's worth, you know, investing in and feeding back, and every child feels like they want to contribute towards it. (David, Int1, #40)
- I think it's really important … at the very start to make sure that whatever we do choose is meaningful for the children and makes them feel empowered and want to contribute. (Aidan, Int1, #81)

Layla was the only TR who articulated having previously encouraged students to choose areas to explore which were of interest to them:

- I try and do this as much as I can in my teaching … to empower the children to come up with … to research and come up with the ideas themselves … they're 10 and 11 [years old], they're very capable of going off and doing research. … And, actually, if we, sort of, did more learning about what social justice is, and then tasking them with "Right, these are the units we do in maths, where do you think, you know, which bits can you tie up together? And which bits do you think are important for elements of the social justice?" … We're thinking about how we can, yeah, empower the children to actually come up with the concepts themselves, as opposed to us telling them "This is important because of these reasons". (Layla, Int1, #30)

Layla's belief that giving students more ownership of their maths learning would raise their levels of engagement was reinforced through the project

- Yeah, I think it's … probably reinforced that it is good practice to involve the children, their opinions, what their learning means to them, what they can do with the learning. … what I've learned through this process is, actually having that particular focus can really help. (Layla, Int2, #14)
- The children were very engaged. I think the fact that they were attributing it to a real-life problem or challenge. So, they really took ownership over setting their own investigations and then understood very much how maths can be related to real life … The taking ownership of it really helped their enthusiasm to the tasks. (Layla, Meet5, #49-52)

Other TRs also began to see the value of tackling issues students saw as of interest to them:

- And giving the children a voice in the classroom to give their ideas, give suggestions, talk what's going on around the world a bit more. (Emma, Int2, #42)
- And I think, once you start to see the children actually grapple with these issues, and form quite well-articulated opinions … I think it's really important that we give them a chance to start to understand the problems, and give them a voice, really, to say what they think. (Rose, Int2, #47)
- The activities that we did came out of things that the children were interested in at the time … and I think that particularly supports our lower attainers. And they felt like they had a bit of a choice in what we were doing. (Kate, Int2, #45-47)
-

4.3.10. Students' increasing appreciation of how mathematics is relevant/applicable to real life

The TRs noticed how students became more willing and able to apply mathematics to solve real-life problems:

- There was a lot more children talking about the scientific aspects of how that affects … you know how we live, whether that be through, you know, energy … and mathematical calculations are so important to this and that without this we can't evolve. (Aidan, Int2, #19)
- I think it's made them understand maths in a broader context and for the wider world. … I think what we've done is more that we've taken maths they already understand and applied it, rather than them learning new maths, if that makes sense. (Layla, Int2, #4)
- I think the major impact is just that they're actually learning how to give an opinion, but they're using maths skills. And understanding that they can apply maths to situations that are not just in the classroom, and things that affect them. (Emma, Int2, #2)

The TRs highlighted how applying mathematics enabled students to develop a greater understanding of social justice issues such as fairness:

- I definitely think it's got them to consider what, like, 'fairness' means and what it looks like, a lot more. … because they've had to have more of a role in making things fair, they probably considered it a little bit more. And I think they've got a much deeper understanding of what 'fairness' means. (Rose, Int2, #2)
- … help them to question things and to look at "Actually, are these numbers fair?" And to question "Is that way that we vote the fairest way?" (Kate, Meet3, #63)
- In my class, once the votes were tallied up and counted, some of the children were like "Ohh", you know, "I wanted to vote for this one", because they realized that the gap between, maybe, number 4 and number 2 wasn't as … you know, if they changed their vote, that might have actually won. (Aidan, Meet5, #107)

The TRS articulated the impact opportunities to apply maths to solve meaningful problems had on students' mathematical learning/understanding:

- I don't think the children realise quite the impact it's had, but I can see that it's had a real impact. They just sit there like "Oh, we're using maths for something else". And now you can see that they are more inclined to, sort of, vote on things and, sort of, suggest that sort of thing. (Kate, Int2, #3)
- I think it's had a really positive impact on the students and in how their understanding of mathematics and the importance of mathematics, not just in the context of a maths lesson, but in the wider world. (Aidan, Int2, #2)

4.3.11. Students growing appreciation of how maths can be used to argue for change

The TRs overcame any initial reluctance they may have had to get students to use maths to argue for change, once they saw how enthusiastically students engaged with these opportunities:

- OK, so why don't we do some voting within our classroom and get the children actively involved in terms of putting forward some ideas that they had for things that they might want to vote on? … And this, I guess, was one of the areas that I was slightly concerned with in terms of my class and how this was going to go, but actually I found all the children were really engaged and were really passionate about putting forward why their idea was the strongest. (David, Meet5, #79)
- So, they're looking at using their maths in all sorts of different things. And, you know, in their play now, they'll say, "Oh, well, shall we vote on what game we're going to play?" And they love a bit of voting now. (Kate, Int2, #9)

The TRs highlighted how students were able to use maths to strengthen their arguments relating to social justice issues:

- So, we, kind of, saw that, when they went off doing their independent task … the children had a better overview at the end and were able to feedback during the plenary, and actually give answers

that had reasoning behind them, rather than just: “This is the answer and that's it.” … the children have more to say about social justice, or fairness, equality, doing the maths, where it made an impact on their own lives, in comparison to when we've looked at fairness, equality, all that, in previous tasks … they just don't have as much explanation with a reason. (Emma, Meet5, #16-19)

- So, the children collated the results of how they commuted to school. We used a tally chart, and they were quite shocked to realise that … the majority of my class, anyway, came to school by the car. … And I think they were quite interested to see how … the maths was actually quite important there to help us, not only just work things out, but interpret the data as well. (Aidan, Meet3, #87-92)
- I was really trying to get them to use, kind of, the numbers behind it to justify. That possibly needed a little bit more time ... But it was really hard for them to not think about what they believed in. But they were all successful, they all managed to do it. They all managed to justify it, and it ended up convincing some of the children anyway, because they switched their vote at the end. (Rose, Meet5, #64)

Kate described the excitement of students when they found out their idea (based on a mathematical argument) was going to be presented to senior leaders in the school for consideration:

- When we told them that, actually, what they were going to do, potentially, could have an impact with senior leadership in the school … and have an impact on the whole school’s play, and who could play where … they were quite speechless … But I think it gave them a bit of a sense of agency over their little lives here. (Kate, Int2, #11)
- [We told them] “you're going to take this to Mr. Kelly and the senior leaders and perhaps they might put it into practice”. … I think they didn't realize, they thought: “Oh, you know, it's all about us and we can do this”. (Kate, Meet5, #36)

4.3.12. Students increasingly able to work collaboratively to solve problems

The TRs described how students were already keen to collaborate with each other in maths lessons:

- … they really, like, seem to like to help each other a lot. So, say like in maths, if one child hasn’t got something right, other children who probably are exceeding in maths are very quick to support other children … they like to support each other and they like to encourage each other to do the maths, which you don't always see in such a young group of children, but they want every child to be getting everything right or doing everything correct. (Emma, Int1, #8)
- And they're working together … I let them move and sit together, to help work it out. So, it's been good to see them talking about maths, and being slightly more engaged. (Rose, Int1, #15)

However, there was also an appreciation that working together effectively was something that students needed to be supported with and that teachers needed to give more attention to:

- It's been … important for me to try and allow them to collaborate more and work together more, particularly in maths lessons, to try and solve problems. And it's probably highlighted, for me, an awareness of how difficult they find it, to collaborate, sometimes. … Because it's actually a skill they need to learn, and you need to help teach … because you realize that children, perhaps, don't really understand what collaboration … good collaboration … should look and sound like. (Rose, Int2, #14-19)
- But I didn't know what is ‘successful’ collaboration … is there a way of measuring that in any more detail? … So, they … collaboratively, as smaller groups, were able to come up with the right answer. So, I suppose, in that sense, then that felt like it was a successful collaboration. And nobody had a different opinion that I could hear. (Layla, Meet3, #27-29)
- We don't do enough of … these activities where they work in teams, and they have to get up in front of their peers and actually present their ideas. (David, Int2, #85)

The TRs described how collaborative working was integral to the way students tackled the activities tried out in the project:

- And then they worked collaboratively to find what … what that actual number was. So, they worked to find out the mean number of cubes, depending what … obviously the number of students in the group. (Layla, Meet3, #27)
- And then we had a really big discussion about how it was unfair that some people's opinions got heard more than others. So, it was interesting to see how they worked collaboratively outside of traditional subjects. (Rose, Meet3, #49)

There was evidence to suggest that increased engagement with meaningful mathematical problems enhanced students' willingness and enthusiasm to engage in collaborative problem-solving:

- And their teamwork was amazing because, you know, sometimes they can be, you know, five- and six-year-olds … The fact that they all worked so well together for so long. They really engaged in it. (Kate, Meet5, #23-25)
- So, we had five different teams … class split into five groups and each of them were trying to convince the class that their idea was best. They were given kind of 10 … 15 minutes to work in groups. We saw some really nice work … they were all given the opportunity to, kind of, share and inputting their ideas and thoughts as to why theirs was the strongest idea. And then they got up and they presented after 15 minutes to the class, why they thought their idea was best. (David, Meet5, #80)
- But there was some really good conversation. I was quite surprised. Again, similar to the other groups, certain children really engaging in the task. (Aidan, Meet5, #86)

This enthusiasm to engage in collaborative problem solving was highlighted by the passion with which students entered into discussions with others:

- … there was some really passionate debate and lots of really good, sensible kind of comments and examples being put forward by the children … And in the lesson that we taught, they were just really passionate about putting across their opinions as well, which is quite nice to see. … It was nice to see kind of the teamwork aspect of it work quite well. (David, Int2, #80-85)
- They found discussing and working out which one was the most damaging … that caused a fair few arguments in class … quite heated discussions. So, it was really interesting to see how they managed to solve it. (Rose, Meet3, #46)
- And then they worked with their talk partner to talk about their views. And there was some quite heated discussion amongst them. And at that point, they were really keen then to come up with some different ideas, which they thought might be fairer. (Kate, Meet3, #63)

5. Summary of key findings

In this section we summarise the key findings from the three separate statistical and thematic analyses.

5.1. Statistical analysis of student survey responses

The main aim was to test the efficacy of the survey in measuring SMA (in particular students' sense of SMA). Having established the validity and reliability of the survey (see sections 5.1.1 and 5.1.2 below), we went on to explore what the outputs might tell us about differences in students' SMA across different key stages and between the start and end of the project (see section 5.1.3 below).

5.1.1. Validity of surveys

The statistical analysis focused on testing the 'criterion validity' of the survey by looking at the extent to which the rankings that students in Aidan's Year 2 class gave to the statements ('actual rankings') correlated with the characteristics exhibited by the students that can be inferred (by the researchers) from their explanatory comments ('predicted rankings'). It should be noted that there was a relatively high frequency of comments in response to statements 1, 3 and 6 from the survey that we interpreted as showing students had misunderstood the statement (and hence not included in the analysis). For statement 5, at least half the students did not make an explanatory comment. These results suggest that the language for statements 1, 3, 5 and 6 might need to be reviewed.

Looking at comments where students were judged to have made an appropriate response to the statement, the statistical analysis (using Spearman's Correlation Coefficient) showed that there was a significant correlation between predicted rankings (based on students' comments) and actual rankings for all 6 questions. Taking into account the difficulty in interpreting the language in the statements highlighted above, this demonstrates a reasonably high level of criterion validity within the survey. In other words, once students were able to access the language, the survey appeared to measure what it was intended to measure.

See section 2.1 for a more detailed explanation of the statistical analysis.

5.1.2. Reliability of surveys

Section 5.1.3 highlights that, with the exception of students in Aidan's class and the results for Question 5, there was no significant difference between students' rankings in the two surveys (conducted 6 months apart), supporting an argument for the 'stability' of the survey.

We tested the 'internal reliability' of the survey by comparing students' responses (rankings) to different questions on Survey 2 (using Spearman's Correlation Coefficient). The results showed that there was no significant correlation between Question 5 and Questions 1, 3, 4 and 6, and a significant negative correlation between Question 5 and Question 2 (the opposite of what we would have expected). This raises further concerns about the efficacy of Question 5 (see section 5.1.1). If we ignore Question 5, of the remaining 10 relationships between pairs of variables (responses), all but one showed a significant positive correlation between responses, indicating high levels of internal reliability. Four of these nine correlations were strong, four were moderate, and one was weak. It is not clear why there was no significant correlation between Questions 1 and 2 (as we would have expected). There were relatively strong and significant correlations between Questions 3 and 6, and between Questions 2 and 4 (displaying two out of the three highest correlation coefficients). Since these pairs of questions were designed to measure the same components of SMA (see section 1.6), this provides further evidence to support the internal reliability of the survey. Interestingly, the strongest correlation was between Questions 1 and 3, which might possibly be explained by the similarity in language between the two statements (both contained the words 'world' and 'better'), despite them being designed to measure different components of SMA.

See section 2.2 for a more detailed explanation of the statistical analysis.

5.1.3. Measures of (sense of) SMA

Given that we were reasonably confident about the validity and reliability of the survey, with the exception of Question 5 (see sections 5.1.2 and 5.1.3), we decided to use the survey to explore whether there were any significant differences between the SMA of students in Key Stage 1 and Key Stage 2, and whether there was any significant increase in students' SMA over the course of the project.

First, we tested (using the Mann-Whitney U Test) for significant differences in responses to each survey question (except Question 5) between the students in Years 1/2 and the students in Years 5/6 (near the beginning and end of their primary school education respectively). The results showed that, on both surveys, students' responses for Questions 4 and 6 were significantly higher for students in Years 1/2 than for students in Years 5/6, whilst there was no significant difference for responses to Questions 1, 2 and 3. The results for Questions 4 and 6 were contrary to what we expected and there may be several possible explanations for this. It might be that (a) the teachers and teacher helpers who supported the KS1 students with their surveys influenced their responses; or (b) experiencing the primary school mathematics curriculum has a negative impact on students' sense of SMA; or (c) gaining more real-life experiences (in and out of school) leads to a growing appreciation amongst students of the challenges that are faced by those wishing to bring about social change.

See section 2.3.1 for a more detailed explanation of the statistical analysis.

Secondly, we tested (using the Wilcoxon Matched-Pairs Signed-Rank Test) for significant differences between survey responses to each question across the two surveys (for those students that had completed both surveys). We compared the responses for all students, for students in each Key Stage and for students in each class. For most groups, there was no significant difference between the two surveys for the responses to Questions 1, 2, 3, 4 and 6. However, there was an exception in Aidan's class, with the test showing a significant increase in rankings in responses to Questions 2, 3 and 6 (all with large effect sizes), with an increase in rankings in responses to Question 4 being only slightly below the significance threshold. This would suggest that there was something unique about Aidan's class, which was the only one of the six classes to show a significant increase in sense of SMA over the course of the project. Interestingly, for Question 5, there was a significant increase in the rankings in responses for four out of the six classes, with a large effect size for Kate's class (Year 1) and a medium effect size for the other three (Emma's Year 1, Aidan's Year 2 and Layla's Year 6). There was also a significant increase in responses to Question 5 for all Key Stage 1 students (with a large effect size).

See section 2.3.2 for a more detailed explanation of the statistical analysis.

5.2. Thematic analysis of student survey responses

We conducted a thematic analysis of the comments made by students in response to the survey questions. We focused on two areas of interest, related to a comparison of survey responses across the two surveys, that had arisen from the statistical analysis.

5.2.1. Comparison of survey 1 and 2 responses for students in Aidan's class

We conducted a thematic analysis of the comments made by students in Aidan's class in response to Questions 2, 3, 4 and 6 from the survey. The findings concurred with the statistical analysis of students' rankings of the statements for these questions (see section 5.1.3 above), which suggested a significant development of students' sense of SMA over the course of the project. Questions 3 and 6 related to appreciating the power of mathematics to support an argument for social change (component 2 of SMA), whilst Questions 2 and 4 related to appreciating the value of working together in mathematics to solve

problems (component 3 of SMA). Hence there is further evidence to suggest that the students in Aidan's class developed these two components of SMA over the course of the project.

We also conducted a thematic analysis of comments made by students in Aidan's class in response to Questions 1 and 5 from the survey (related to component 1 of SMA). Whilst there was no significant increase shown in the rankings to these questions in the statistical analysis, the thematic analysis did suggest some development in appreciating the links/applications between mathematics and social justice issues (component 1 of SMA). However, this evidence of development of component 1 of SMA was limited to comments made by 4-6 students in Aidan's class in response to Questions 1 and 5.

5.2.2. Comparison of survey 1 and 2 responses to Question 5 in Emma's class

We conducted a thematic analysis of the comments made by students in Emma's class in response to Question 5 from the survey. The evidence from this thematic analysis suggested that the significant increase in the rankings in response to this Question (also witnessed in 3 other classes) was due to a common misinterpretation of the statement '*Maths can be used to mislead people'* as something along the lines of *'Maths can be confusing'*. The apparent increase in agreement with this statement may relate to students beginning to see mathematics as less straightforward and more complex, perhaps as they developed a greater appreciation of the links between mathematics and real-life issues (related to component 1 of SMA). We concluded that a more appropriate statement for assessing component 1 of SMA in future might be: *You need maths to fully understand real-life issues*.

5.3. Thematic analysis of research group meetings and interviews

Three themes were identified from the thematic analysis of the research group meetings and interviews with teacher researchers (TRs). For each theme, subthemes were identified as detailed in the table below:

Theme	Subthemes
1. Teachers' developing views of mathematics (see section 5.3.1. below)	• Teachers' varying relationships with mathematics • Teachers' development of a broader view of maths within the curriculum • Teachers' recognition of the legitimacy of social justice issues in maths learning • Teachers' appreciation that young children can engage with maths and social justice (see sections 4.3.1 to 4.3.4 for more detailed descriptions/supporting evidence)
2. Teachers' developing agency and efficacy (see section 5.3.2. below)	• Teachers beginning to challenge students' beliefs about maths • Teachers rethinking strategies and approaches to teaching maths • Teachers beginning to navigate constraints of curriculum • Teachers appreciating the importance of collaboration and peer support (see sections 4.3.5 to 4.3.8 for more detailed descriptions/supporting evidence)
3. Students' developing socio-mathematical agency (see section 5.3.3. below)	• Students taking greater control over their own learning • Students' increasing appreciation of how mathematics is relevant and applicable to real life • Students growing appreciation of how maths can be used to argue for change • Students increasingly able to work collaboratively to solve problems (see sections 4.3.9 to 4.3.12 for more detailed descriptions/supporting evidence)

A summary of each of the three themes can be found below. More detailed descriptions of the twelve subthemes, accompanied by supporting evidence, can be found in section 4.3.

5.3.1. Theme 1: Teachers' developing views of mathematics

The Teacher Researchers (TRs) exhibited different relationships with maths ranging from fear and anxiety (Kate) to dislike of the subject (Emma, Rose, Aidan). In contrast, Layla described herself as passionate about maths. All TRs expressed a desire to overcome the constraints imposed by a narrow maths scheme of work in developing a broader and richer maths curriculum, which embraced discussion and debate and could be

applied to other areas of the curriculum. TRs articulated the need to make maths more meaningful and purposeful for students by relating it to real life experiences. They appeared successful in beginning to realise this aim in their practice and described the positive impact this had on student engagement. TRs hadn't necessarily made a strong link between maths and social justice before becoming involved in the project. However, they demonstrated a strong interest in, and a developing commitment towards doing so. There was an appreciation that some people might question the legitimacy of tackling social justice issues in maths lessons and of the need to establish genuine links between maths and social justice when doing so. The TRs recognised the challenges of engaging younger students in social justice issues, particularly in maths lessons, although they developed a greater appreciation of the importance of doing so.

5.3.2. Theme 2: Teachers' developing agency and efficacy

The Teacher Researchers (TRs) showed a willingness to challenge some students' negative views about maths and to demonstrate to them how maths can be applied to real life situations. They had some success in building students' confidence, particularly those exhibiting anxiety towards the subject, and enabling them to see how maths could be made more meaningful and purposeful. However, some negativity towards maths was difficult to overcome and some students were still put off engaging with projects when they recognised that they included some mathematical content. The TRs welcomed the opportunity to focus on developing their own thinking and practice, and they believed the project was successful in facilitating this. They began to question assumptions underpinning existing practice, including pre-conceived ideas about students' abilities. Critically reflecting on practice prompted them to adopt more collaborative, discursive, problem-solving teaching approaches, which they saw as being more inclusive and resulting in higher levels of engagement and participation. Whilst the mastery-style maths schemes of work used in both schools claimed to promote solving real-life problems in greater depth, in reality there was too much content to get through to allow this to happen. There was also a perception of the wider curriculum being too content-laden, which was seen as a constraint by the TRs on their efforts to bring social justice issues into learning maths. However, they described how they managed to overcome these constraints by identifying and establishing strong and genuine links between maths and social justice issues. Whilst limited time to plan appropriate activities was also seen as a constraint, TRs recognised the potential benefits for students of doing so. TRs also recognised the potential benefits of participating in the project on their own professional development. Being part of a network of teachers, and sharing ideas with colleagues from different schools, was seen as having a positive impact on their thinking and broadening their perspectives on practice. They recognised the importance of support from senior teachers for enabling this to happen and for having a wider impact on practice across the school.

5.3.3. Theme 3: Students' developing socio-mathematical agency

Whilst the Teacher Researchers (TRs) sometimes adapted their teaching to the needs of students by providing tasks at an appropriate level of challenge (typically based on 3 levels of difficulty), this was limited and sometimes required teachers to moderate the students' choices. However, in order to enhance engagement with mathematics, TRs appreciated the need to provide more meaningful tasks over which students would feel a greater sense of ownership. The practice of allowing students to use maths to explore areas they were interested in became more widespread amongst the TRs (only one TR described having done this before the project). Students became more enthusiastic in solving real life mathematical problems when these drew on meaningful contexts, which enhanced their understanding of both mathematics and social justice issues. The TRs were impressed with the extent to which students embraced the opportunity to use maths in arguing for change. They reported how students were able to use maths to strengthen their arguments and became even more engaged when they knew their arguments would be listened to. TRs highlighted how students were keen to work collaboratively in maths but often needed encouragement and support to do so effectively. Collaborative working featured in the activities tried out in the project and the increased engagement with meaningful mathematical problems appeared to

enhance students' willingness to work with others. Students demonstrated passion in the way they entered into discussions with others, illustrating the enthusiasm with which they engaged with collaborative problem solving as part of the project.

6. List of references

Braun, V. & Clarke, V., 2022. *Thematic analysis : A practical guide.* Los Angeles: SAGE.

Gutstein, E., 2006. *Reading and writing the world with mathematics: Toward a pedagogy for social justice.* New York: Routledge.

Manyukhina, Y. & Wyse, D., 2019. Learner agency and the curriculum: A critical realist perspective. *The Curriculum Journal,* 30(3), pp. 223-243.

Mason, J., Burton, L. & Stacey, K., 1985. *Thinking mathematically.* Harlow: Addison-Wesley.

OECD, 2018. *The Future of education and skills: Education 2030,* Paris: Directorate for Education and Skills - Organisation for Economic Co-operation and Development (OECD).

Schoenfeld, A., 2012. Problematizing the didactic triangle. *ZDM Mathematics Education,* 44(5), pp. 587-599.

Skovsmose, O., 2021. Mathematics and crises. *Educational Studies in Mathematics.*

UNESCO, 2015. *Rethinking education: Towards a global common good?,* Paris: United Nations Educational, Scientific and Cultural Organisation.

Wright, P., 2016. Social justice in the mathematics classroom. *London Review of Education,* 14(2), pp. 104-118.

Wright, P., 2017. Critical relationships between teachers and learners of school mathematics. *Pedagogy, Culture and Society,* 25(4), pp. 515-530.

Wright, P., 2021. Transforming mathematics classroom practice through participatory action research. *Journal of Mathematics Teacher Education,* 24(2), pp. 155-177.

Wright, P., 2022. *Conceptualising and operationalising socio-mathematical agency.* Proceedings of the 12th Congress of the European Society for Research in Mathematics Education. Bolzano, Italy, CERME.

Wright, P., Carvalho, T. & Fejzo, A., 2022. Visible mathematics pedagogy: A model for transforming classroom practice. *Educational Action Research,* 30(2), pp. 168-191.

Appendix 1 (Student survey)

PMSJ Student Survey (anonymous)

Guidance for teacher researchers in implementing survey:

- Please share the following information with students (e.g. paraphrase the key points).
- Give out response sheets ensuring the correct Unique Identifier is given to each student.
- There are 6 questions to complete (the response sheet is double sided).

Information for students:

- Your teacher/classroom helper will explain how to complete the survey.
- Your teacher/classroom helper will also explain the information below.
- Your teacher/classroom helper may also help you to complete the survey.
- For each statement, tick one box to show how much you agree.
- Then explain your reasons in the box below each statement.

About the research project:
We are inviting you to complete this survey as part of a research project which is being carried out by a research team including your teacher. The aim of the research project is to explore how students can work together and think about how maths can be used to make the world a better place. Your teacher will be trying out some ideas with you in maths lessons as part of the project. The findings will be written up by the research team and shared with other teachers and researchers. This will be through writing a brief report, blogs and journal articles, and through presenting at conferences.

About the survey:
It is completely up to you if you wish to take part in this survey.

If you do not wish to take part, then you should not write anything on the survey and return the blank survey to your teacher. There will be no consequences if you choose not to take part and you will be given a different activity to do.

If you choose to take part, then you can complete as much of the survey as you like. You can leave a question blank if you do not wish to answer it. Your answers will be used to see how successful the research project has been. The survey is completely anonymous so the research team will not be able to tell which comments were made by you. Your comments may be used in writing up the findings from the research project, but nobody will know that the comments were made by you.

Please ask your teacher before starting the survey if you have any questions or concerns.

PMSJ Survey – Student response sheet [Insert Unique identifier here, e.g. A1]

Teacher: [insert name of class teacher/TR]

1. Maths helps people to understand the world better.			
Tick one box only:			
disagree a lot ☹☹	disagree a bit ☹	agree a bit ☺	agree a lot ☺☺
Explain below why you think that:			
…… ……			

2. It is good to solve maths problems with other people.			
Tick one box only:			
disagree a lot ☹☹	disagree a bit ☹	agree a bit ☺	agree a lot ☺☺
Explain below why you think that:			
…… ……			

3. Maths can be used to make the world a better place.			
Tick one box only:			
disagree a lot ☹☹	disagree a bit ☹	agree a bit ☺	agree a lot ☺☺
Explain below why you think that:			
…… ……			

Continued on page 2 …

… Continued from page 1 [Repeat Unique identifier here, e.g. A1]

4. You can do more in maths when you work with others.			
Tick one box only:			
disagree a lot ☹☹	disagree a bit ☹	agree a bit ☺	agree a lot ☺☺
Explain below why you think that:			
…… ……			

5. Maths can be used to mislead people.			
Tick one box only:			
disagree a lot ☹☹	disagree a bit ☹	agree a bit ☺	agree a lot ☺☺
Explain below why you think that:			
…… ……			

6. You can use maths to help you explain something.			
Tick one box only:			
disagree a lot ☹☹	disagree a bit ☹	agree a bit ☺	agree a lot ☺☺
Explain below why you think that:			
…… ……			

Thank you for completing the survey.

Appendix 2 (Ethical approval)

Information sheet for teacher researchers (research participants)

UCL Research Ethics Committee approval ID number: REC1562

You will be given a copy of this information leaflet.

Title of research project:

Primary Maths and Social Justice: Developing students' collective mathematical agency

Lead researchers:

- Pete Wright* (Associate Professor, UCL Institute of Education): pete.wright@ucl.ac.uk
- Caroline Hilton (Lecturer, UCL Institute of Education): caroline.hilton@ucl.ac.uk
- Joel Kelly (Assistant Headteacher, The Blue School): joel.kelly@theblueschool.com

*Correspondence should be directed towards Pete Wright.

Invitation to take part in the above research project

We would like to invite you to take part in the above research project as a teacher researcher. Please read the following information about the project carefully before deciding whether or not you would like to take part. Note that your participation in the research team is entirely voluntary.

If you do decide to take part in the research project, you should sign the attached consent form and return it to one of the lead researchers. You will also need to seek the approval of your headteacher for you to take part in this research (they will also need to sign the consent form). You should keep this information sheet for future reference. You can withdraw at any time without giving a reason and without it affecting any benefits that you are entitled to. If you decide to withdraw you will be asked what you wish to happen to the data you have provided up to that point.

If you do not wish to take part in the research project, please return the blank consent form and information sheet to one of the lead researchers. You do not have to give a reason for this and there will be no consequences for you if you decide not to take part.

Background to the project:

The research project will explore how primary school teachers can pursue an interest in social justice issues in teaching mathematics. We will explore the potential of a model of participatory action research (PAR) for building and maintaining teachers' agency and self-efficacy in developing their own practice (Wright et al, 2020). We will draw on a conceptualisation of teaching mathematics for social justice to explore ways of developing students' critical mathematical understanding and collective agency in primary school classrooms (Wright, 2016). We see these dispositions as vital for enabling today's learners to play a future role in addressing the environmental, economic and social challenges facing our society, reflecting recent calls for a more humanistic school curriculum (OECD, 2018; UNESCO, 2015). We anticipate the project will help us develop the concept of 'socio-mathematical agency', which we define as the ability to use mathematics effectively to argue collectively for social change.

Aims of the project:

1. To establish mechanisms and structures that enhance primary school teachers' agency in tackling social justice issues in mathematics lessons.
2. To develop effective strategies that can be used by teachers in primary schools to enhance students' critical understanding of mathematics and collective mathematical agency.

Research design and timescale:

We will establish a research team consisting of the 3 lead researchers and approximately 6 to 8 teacher researchers in local schools who have expressed an interest in tackling social justice issues in teaching mathematics. In line with the participatory and collaborative principles of PAR, the final research design will be discussed and agreed by the research team. The following information provides an initial structure for the project and outlines clearly the time commitments that teacher researchers will be expected to make towards the project.

- The project will run from November 2021 to July 2022.
    - It may be a possible to continue beyond July 2022 (if teacher researchers wish to).
- The research team will meet once every half-term for 1 to 1½ hours (5 meetings in total).
    - Some of these meetings (including the first meeting in November) will be held face-to-face at [East Primary School] (likely to start at 4.30pm).
    - Some of these meetings will be held online (likely to start at 4pm).
    - Selected parts of the research team meetings (i.e. those in which the focus is on evaluating the teaching ideas) will be recorded, and these recordings will form part of the data to be collected and analysed (to help address aim 1 of the project).
    - A draft schedule of meetings is included as an appendix.
- Teacher researchers will plan, teach and evaluate one research lesson in the Spring Term and one research lesson in the Summer Term.
    - These will involve trying out teaching ideas planned during research team meetings.
    - They will also involve collecting some student data to help evaluate the success of the teaching ideas during research team meetings through student surveys (and possibly through interviews with students and video recordings of lessons).
    - The design of the student survey, and protocols for its administration, will be discussed and agreed by the research team during research team meetings.
    - The responses from student surveys will form part of the data to be collected and analysed (to help address aim 2 of the project).
    - The research team will also decide whether to implement any other data collection tools.
- Each teacher researcher will be interviewed by one of the lead researchers once near the beginning of the project and once near the end of the project.
    - Each interview will each last approximately 30-40 minutes and will be conducted in the teacher researcher's own school.
    - The questions will focus on evaluating teachers' agency and self-efficacy in developing their own practice.
    - The interviews will be audio-recorded, and these recordings will form part of the data to be collected and analysed (to help address aim 1 of the project).
- Each TR will maintain a research journal to capture the development of their thinking and classroom practice over the course of the study.
    - Research journals will be used to record reflections on discussions during research team meetings and the responses of students during the research lessons.
    - Research journals will be used as prompts for TRs to present their evaluations of the teaching ideas they have tried out during meetings.

- The research journals themselves are personal reflections and will not form part of the data to be collected as part of this project.

Benefits and possible risks of taking part:

This is an unfunded project so there are no benefits for taking part in terms of financial resources for yourself or your school. However, it is hoped that by taking part in the project you will benefit by developing your classroom practice and gaining further insight into educational research in the field of mathematics education. It is also hoped that your school will benefit from developing policies and practice which will support its current development priorities. More generally, your participation may provide insight for other practitioners and researchers with an interest in these areas, or help to shape future research in the field.

I do not anticipate that this research project poses significant risk to yourself or your students. However, it is possible that by encouraging you to reflect critically on your current practice or to conduct surveys with your students, you may experience some discomfort or anxiety. In order to minimise these risks, the student survey will be conducted anonymously (unique identifiers will be used solely for the purpose of matching the first survey response with the second survey response for each student). Questions will be restricted to seeking students' feedback on the mathematical activities they have been working on, reflecting on the mathematics knowledge they have learned and how they might use this knowledge to tackle real life problems related to social justice issues. If you do experience any discomfort or anxiety during this research, you should inform Pete Wright or one of the other lead researchers as soon as possible. Should you wish to raise a complaint about the way the research has been conducted, you should contact the Chair of the UCL Research Ethics Committee - ethics@ucl.ac.uk

How will the audio recordings of the meetings and interviews be used?

The audio recordings of your activities that are made during the interviews and selected parts of meetings will be transcribed by one of the lead researchers and anonymized before being used for analysis, after which the original recordings will be deleted. The transcripts will be used only for analysis and illustration in reports by the lead researchers of the findings from the research project, journal articles and presentations at conferences/events. The transcripts of recordings and data analysis files may be used by other researchers to verify the results of this research project or in conducting future research. No other use will be made of them without your written permission, and no one outside the project will be allowed access to the original recordings.

All the information about you that is collected during the course of the research will be kept strictly confidential. Please note that confidentiality may be limited or conditional in that the researcher has a duty of care to report to the relevant authority possible harm/danger to the participant or others. You will not be able to be identified in any ensuing reports or publications, unless you give your written permission for your identity to be disclosed.

Data Protection Privacy Notice

The controller for this project will be University College London (UCL). The UCL Data Protection Officer provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. This 'local' privacy notice sets out the information that applies to this particular study. Further information on how UCL uses participant information can be found in our 'general' privacy notice: For participants in research studies, click here

The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices. The lawful basis that will be used to process your personal data are: 'Public task' for personal data. Your personal data will be processed so long as it is required for the research project. If we are able to anonymise or pseudonymise the personal

data you provide we will undertake this, and will endeavour to minimise the processing of personal data wherever possible. If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk. If you remain unsatisfied, you may wish to contact the Information Commissioner's Office (ICO). Contact details, and details of data subject rights, are available on the ICO website at: https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/individuals-rights/

Thank you for reading this information leaflet. Should you require any further information, please do not hesitate to contact Pete Wright or one of the other lead researchers.

References:

OECD, 2018. *The Future of education and skills: Education 2030*, Paris: Organisation for Economic Co-operation and Development. https://www.oecd.org/education/2030-project/

UNESCO, 2015. *Rethinking education: Towards a global common good?* Paris: United Nations Educational, Scientific and Cultural Organisation. https://en.unesco.org/news/rethinking-education-towards-global-common-good-launched-4-november

Wright, P., 2016. Social justice in the mathematics classroom. *London Review of Education*, 14(2), pp. 104-118. https://www.scienceopen.com/hosted-document?doi=10.18546/LRE.14.2.07

Wright, P., Carvalho, T. & Fejzo, A., 2020. *MTCP: A Model for Transforming Classroom Practice*. Visible Maths Pedagogy Research Project. https://visiblemathspedagogy.files.wordpress.com/2020/05/mtcp-model-for-transforming-classroom-practice.pdf

Appendix – draft schedule of meetings:

Term	Date	Aims	Location	Time
Au2	30.11.21	Meet the team Engage with the ideas Project Design	[East Primary School]	4.30pm - ?
Sp1	18.1.22	Plan research lessons	[East Primary School]	4.30pm - ?
Sp2	22.3.22	Evaluate	Google Meet	4pm - ?
Su1	24.5.22	Plan research lessons	[East Primary School]	4.30pm - ?
SU2	28.6.22	Evaluate	Google Meet	4pm - ?

Consent Form for Teacher Researchers

Title of research project:
Primary Maths and Social Justice: Developing students' collective mathematical agency

There are three researchers leading this research project:

- Pete Wright* (Associate Professor, UCL Institute of Education): pete.wright@ucl.ac.uk
- Caroline Hilton (Lecturer, UCL Institute of Education): caroline.hilton@ucl.ac.uk
- Joel Kelly (Assistant Headteacher, The Blue School): joel.kelly@theblueschool.com

*Correspondence should be directed towards Pete Wright.

If you are happy to participate in this study, please complete this consent form, sign it, ask your headteacher to sign it to indicate that they approve of your participation in the study, and return the completed form to Pete Wright or one of the other lead researchers.

	Yes	No
I have read and understood the information leaflet about the research project. I have had the opportunity to ask questions. Any questions I've asked have been answered to my satisfaction.		
I understand that my contributions towards discussions during selected parts of research team meetings will be audio recorded.		
I agree to be interviewed twice as part of the research project and I understand that these interviews will be audio recorded.		
I understand that I can withdraw from the project at any time, and that if I choose to do this, any information I have provided will not be used.		
I understand that I can contact one of the lead researchers at any time and ask that the information I have provided is removed from the research project records.		
I understand that the findings of the research project will be written up as reports (available online), published in blogs and journal articles, and presented at conferences and events.		
I understand that all personal information will remain confidential and that all efforts will be made to ensure that I cannot be identified in any of the published documents.		
I agree for the anonymised written record of the interview discussions and research team meeting discussions in which I take part to be stored securely.		
I understand that other researchers may be allowed access to this written record, so that they can verify the results of this research project or carry out future research.		

Name of Teacher Participant: ……

Signature of Teacher Participant: ……

Date: ……

Headteacher's approval for you to participate in this study:

Name of school: ……

Name of Headteacher: ……

Signature of Headteacher: ……

Date: ……

Information for students and parents/carers

This information will be shared with all students being invited to participate in the research during class time and shared with all parents/carers of these students via the normal school parent/carer communications channels (the 'parents app' at [West Primary School] and Google Classroom at [East Primary School]).

Information for Parents/Carers

Dear Parent/Carer

Please see the information below about a research project being carried out at the school. We would like to invite your child to take part in two short surveys on an entirely voluntary basis (see details below). If you do not wish your child to take part in the surveys, or if you have any questions or concerns about the research, or require any further information, please contact your child's teacher [insert school email address of class teacher/TR]. Alternatively, you can contact one of the three lead researchers (see contact details in the 'Additional information' section below).

The following information will be shared with your child during class time.

Information for students

Dear student

Your teacher [insert name of class teacher/TR] is one of six teachers from [East Primary School] and [West Primary School] taking part in a research project alongside Mr Kelly from The Blue School and two researchers from UCL Institute of Education.

The aim of the research project is to explore how students can work together and think about how maths can be used to make the world a better place. Between January 2022 and July 2022, your teacher will be trying out some ideas with you in maths lessons as part of the project. The findings will be written up by the research team and shared with other teachers and researchers. This will be through writing a brief report, blogs and journal articles, and through presenting at conferences.

We are inviting you to take part in two short surveys which will take place during lesson time. We would be very grateful if you would take part in this exciting new research. However, it is completely up to you if you wish to take part in these surveys.

If you do not wish to take part, then you should not write anything on the survey and return the blank survey to your teacher. There will be no consequences if you choose not to take part and you will be given a different activity to do.

If you choose to take part, then you can complete as much of the survey as you like. You can leave a question blank if you do not wish to answer it. Your answers will be used to see how successful the research project has been. The survey is completely anonymous so the research team will not be able to tell which comments were made by you. Your comments may be used in writing up the findings from the research project, but nobody will know that the comments were made by you.

Please ask your teacher if you have any questions or concerns about the project.

Additional information about the project:

The full title of the research project is: *Primary Maths and Social Justice - Developing students' collective mathematical agency*

The research is being coordinated by three lead researchers:

- Mr Joel Kelly (Assistant Headteacher, The Blue School): joel.kelly@theblueschool.com
- Dr Pete Wright (Associate Professor, UCL Institute of Education): pete.wright@ucl.ac.uk
- Dr Caroline Hilton (Lecturer, UCL Institute of Education): caroline.hilton@ucl.ac.uk

The research has been approved by the UCL Research Ethics Committee (approval ID number: REC1562).

Benefits of research and possible risks of taking part:

We anticipate that your child's participation in the project will help teachers in the school (and teachers in other schools) to develop classroom practice that will benefit your school and society in general. Their participation may also provide insight for other teachers and researchers with an interest in these areas.

We do not anticipate that this research project poses any significant risk to your child. Questions in the surveys will be restricted to asking for students' feedback on the maths activities they have been working on, what they have learned and how they might use this to tackle real life problems. If your child does experience any discomfort or anxiety during the research, they should inform their teacher as soon as possible.

If you have any concerns about the way the research has been conducted, you should contact one of the lead researchers or the Chair of the UCL Research Ethics Committee - ethics@ucl.ac.uk

Data Protection Privacy Notice

The controller for this project will be University College London (UCL). The UCL Data Protection Officer provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. This 'local' privacy notice sets out the information that applies to this particular study. Further information on how UCL uses participant information can be found in our 'general' privacy notice: For participants in research studies, click here

The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices. The lawful basis that will be used to process your personal data are: 'Public task' for personal data. Your personal data will be processed so long as it is required for the research project. If we are able to anonymise or pseudonymise the personal data you provide we will undertake this, and will endeavour to minimise the processing of personal data wherever possible. If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk. If you remain unsatisfied, you may wish to contact the Information Commissioner's Office (ICO). Contact details, and details of data subject rights, are available on the ICO website at: https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/individuals-rights/

Thank you for reading this information Should you require any further information, please do not hesitate to contact one of the lead researchers.