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Mathematics Teaching and Global Challenges: Part Two

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In this article, we continue a presentation and discussion of tasks designed for use in the secondary mathematics classroom from Part One (Brown et al., 2021), which aim to link the teaching and learning of mathematics to some of the global challenges facing the world. We (authors) are newly qualified teachers and PGCE tutors. In Part One, we presented and reflected on tasks that had been put to use in school; the examples presented and discussed here had been developed, during the PGCE year 2019-20, for use in the Spring of 2020; global events of the coronavirus pandemic were felt locally through school closures and moving from planning to action with these tasks was postponed. Here, we offer brief descriptions of tasks and an indication of thinking on how we might use them. The different sections are written by a single teacher and in a final section the three tutors offer some concluding thoughts across this article and Part One.

Before getting to the tasks themselves, we offer some thoughts from the contributing teachers, in response to the concern that could be raised, that there is just no time in the curriculum to deal with global challenges in mathematics lessons:

The activities can be viewed as extension exercises. In this way, no teaching time would be lost from your lesson schedule, and it could be a useful way of motivating students to answer questions, as well as helping them to see how the abstract skills that they've learned on this topic can be applied to real-world scenarios.

It can be difficult to plan for student engagement in an ‘ordinary’ lesson. The beauty of addressing a global challenge is that you don’t have to worry about engagement, it seems to happen magically by itself …

As mathematics teachers, it seems that our job is to translate the numeracy of our environments into manageable mathematical problems which both enrich the learning of our students, and help them to understand their place in their environments, alongside others. To this end, learning about how to meaningfully interpret data that we as a population are being exposed to on a daily basis, to help us make informed decisions which we can justify mathematically and morally, becomes important.

While Global Challenges might sound like something reserved for a PSHE lesson, they are easier and more efficient to implement and discuss in the context of a mathematics lesson than one might expect. This is due to the issues being rooted in mathematics and their understanding being directly connected to the Mathematical skills students possess. A knowledge of mathematical skills is essential for comprehending the implications of global challenges. You can choose a global issue and mould the mathematics behind it into lesson plans that follow the National Curriculum. Whether it is to give meaning to the topics already studied by showing their impact in real-life scenarios, or to pitch the introduction of a new topic by presenting it in a compelling context, I believe the implementation and discussion of those issues would increase students’ engagement with the subject, having a very limited impact on the planning and delivering of the curriculum.

Birth and death - Hansel Kurian

Related content: ratio, using ratio notation, writing ratios in the form 1:n, analysing large data sets in spreadsheets

Ratio and Proportion is a topic with many applications in real-world contexts, and so the activity I had planned to teach in March 2020, to my Year 9 class (before we were removed from our placements due to the COVID-19 lockdown), looked at applying ratio calculations to birth data from the Office of National Statistics (ONS). While I have not yet had the opportunity to test this task in my lessons, this investigation-style task will provide an opportunity for students to observe how skills they had learned in the classroom could be applied to more open-ended problems.

The idea for this activity has also been inspired by the introduction of "large data sets" into the A-Level curricula. This appears to have helped students enjoy working on the statistics elements of the A-Level course by aiding them in applying techniques that they have learned in class to real-world examples of data (Proffitt, 2020), and I would aim to emulate this student engagement with an activity providing room for group discussion on how to make sense of the data at hand. The amount of data given in these sets may prove to be overwhelming, especially for those who have not worked with large data sets before, so the activity is designed to get students to focus on smaller data subsets for each question to remedy this.

This activity would be based in a computer room to allow each student to investigate the concepts at their own pace, with the latter questions in each task increasing in complexity and demanding more reasoning skills. Before letting the students log on, I would ask them some starter questions on writing ratios in the form 1:n. This reinforces the main skill that would be required to access the tasks. Then, I would direct students to the spreadsheets on the ONS website (with instructions given both live on-screen and printed on the worksheet), where students would answer the questions posed on the worksheet.

Ultimately, this could end in a group discussion, with students sharing their ideas with the rest of the class on which statistics stand out the most to them, or to noting any disparities between data for each country. This would be supported by the reasoning questions given in the latter part in each task to give students concrete ideas of how to interpret the data in front of them.

Ratio Investigation

Starter questions

1. Write 6 : 4 in the form n : 1.

2. There are 3 cupcakes for every candy bar. Find the ratio of cupcakes to candy bars in the form 1 : n.

For these ratio tasks, you can give any decimal amounts to 3dp.

Task 1: Births by gender/country

- Search: ons "all data related to live births", click first result
- Once on ONS website, make sure "dataset" box is unchecked; you should see ~144 data results
- Download: "Number of live births by sex, parity and country of birth of mother, England and Wales, 2014 to 2018" spreadsheet
- Go to "Table 1" sheet

(a) Write the ratio of male to female births in the form 1 : n for the following countries:

USA China Afghanistan

(b) Write the ratio of male to female births in the form 1 : n for any three other countries on that list.

(c) What would a male : female = 1 : 1 birth ratio tell us about the male births compared to female births in that country?

(d) Looking at your answers to parts (a), (b), which country has the highest number of female births compared to males?

(e) Looking at your answers to parts (a), (b), which country has the highest number of male births compared to females?

Task 2: Births by gender/child number

- Search: ons "all data related to live births", click first result
- Once on ONS website, make sure "dataset" box is unchecked; you should see ~144 data results
- Download: "Number of live births by sex, parity and country of birth of mother, England and Wales, 2014 to 2018" spreadsheet
- Go to "Table 1" sheet

(a) Show that, for England, the ratio (including both male and female) "All live births : First child" is 2295839 : 930730. Write this in the form 1 : n.

(b) For Somalia, write the ratio "All live births : First child" in the form 1 : n.

(c) Can you think of and/or look up a real-world reason as to why your answers in parts (a) and (b) are different?

(d) Repeat the process in part (a) for at least another country of your choice – comparing this to England. Can you give any real-world reasons for why this ratio is different/similar to your previous answers?

(e) Over the four year period 2014-2018, show that the average number of births per year in England (including both males and females) is roughly 574000.

(f) How has this average number changed over the years?

Look up "average live births per UK per year" to find other sources for this.

GDP and life expectancy - Lucy Morris

Related content: Correlation; lines of best fit; representing data; percentages

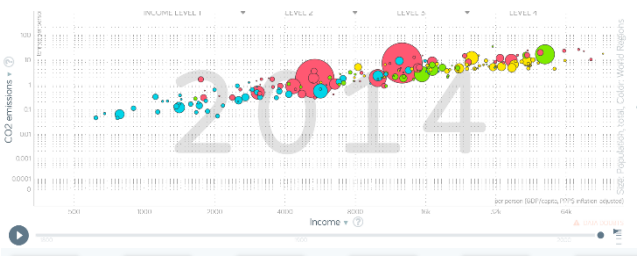
At the beginning of 2020, I read the book Factfulness by Hans Rosling. I was inspired by how much I learned about the world from reading it. I began to play around with the graphics created on Gapminder, the author's website of interactive data visualisations. I confess that statistics has never been of interest to me, and I have always dismissed it as the boring part of mathematics. However, when I was playing with these infographics and learned about the world in an interactive way, I gained an appreciation of looking at, and playing with, data. I agree with Rosling, Gapminder does "bring statistics to life''.

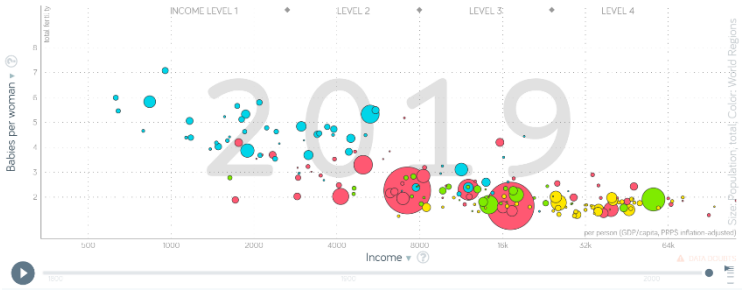
With my newfound appreciation of statistics, I wanted to make the statistics module I was planning to teach to year 9 exciting. I wanted to leave a lasting impression of statistics and show the students that it is certainly not boring. I think Gapminder is the perfect tool to do so.

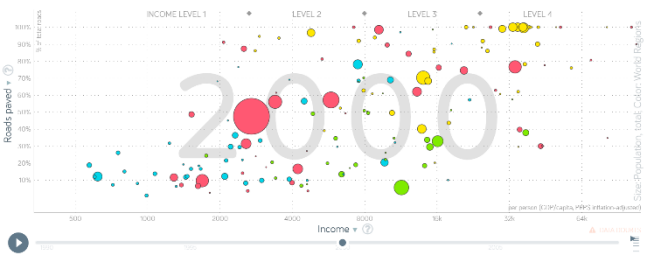
I decided that I would present the class with this question. "How does a country's GDP affect a person's life?'' This would be the introduction of a stats mini project to come at the end of the topic. To begin with, I would let students have a play with the website and get them to change the y-axis to different parameters.

I would then challenge them to find a graph with a positive correlation, a negative correlation, and no correlation. I think this is an interesting question as it makes you think about how income would affect a particular aspect of a person's lifestyle. Sometimes the graphs produced are surprising. To use a direct quote from Rosling: *"The majority of people in wealthy countries believe the rest of the world is worse off than they actually are".*

After a bit of a playing with that I would invite the students to pick something they are interested in to be represented on their y-axis. For the rest of the project I would ask them to explore that chosen parameter. They could comment on the correlation, and the change in correlation over time. They could select some countries to track over time or look for patterns with continents - there is so much scope for exploration. Some students may find







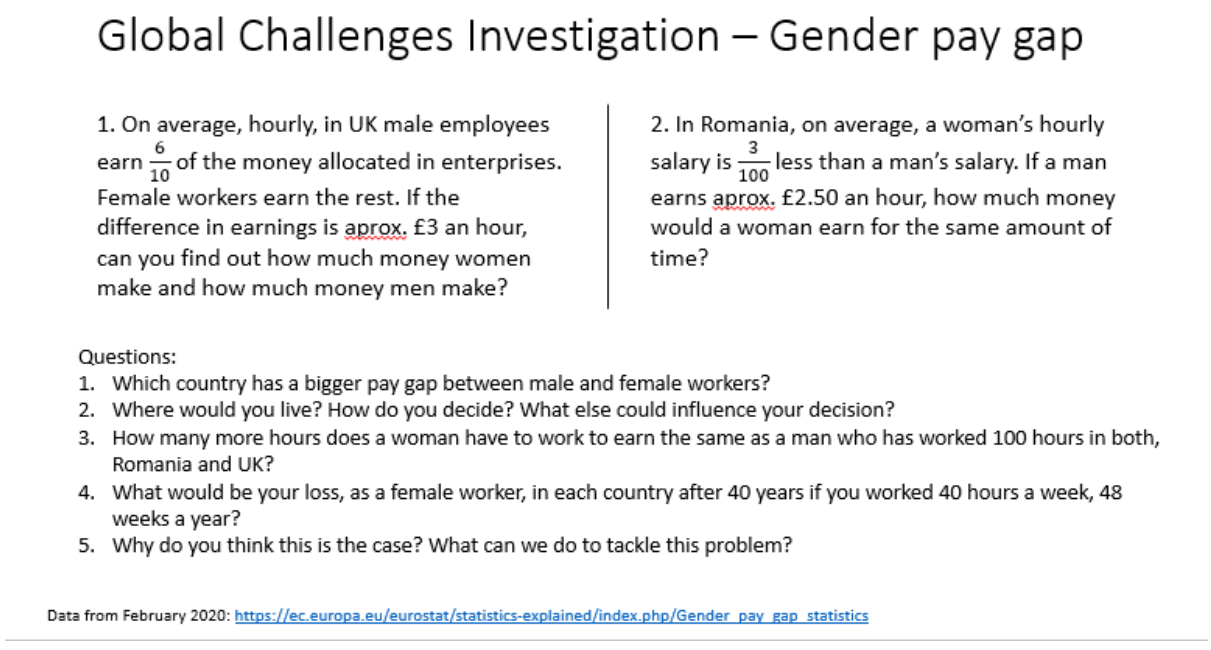
this an overwhelming website - it would be important to give time for an introduction to using it. There are some sombre data sets to be aware of: child mortality, murders, cancer. I did not have the opportunity to do this activity with the class due to school closure. However, I will do this in the future, as statistics is so much more than finding the mean shoe size in the class.

Gender equality - Ioana Sebe

Related content: Finding fractions of a quantity; reverse fractions; operations with fractions and decimals; decimal comparison

Gender equality and the empowerment of women have been central issues in the progression of our society over the past century, especially as it has been recognised that they are pivotal for addressing the other global challenges and support sustainable development in all areas (Millennium Project, 2017). Even though notable strides have been made in recognising the issues and improving equality for women across the world, there are still significant challenges to overcome. As an example, according to the Millennium Project (2017), even though women account for 52% of the global work force, their labour force participation rate is 46%, while that of men is 76%. Furthermore, women are paid up to 35% less than men (Millennium Project, 2017).

I believe it is important for these issues to be recognised and discussed as part of students' education. In this regard, Mathematics offers the perfect opportunity as the concepts studied are central to these problems' exploration and investigation. This motivated me to create a resource which intends to raise awareness and develop understanding towards the challenge. Moreover, the task aims to offer purpose and significance to the mathematical concepts considered through the conversations and reflections that arise from placing these ideas in the context of gender equality.



Global Challenges Investigation – Gender pay gap

1. On average, hourly, in UK male employees earn $\frac{6}{10}$ of the money allocated in enterprises. Female workers earn the rest. If the difference in earnings is aprox. £3 an hour, can you find out how much money women make and how much money men make?

2. In Romania, on average, a woman's hourly salary is $\frac{3}{100}$ less than a man's salary. If a man earns aprox. £2.50 an hour, how much money would a woman earn for the same amount of time?

Questions:

1. Which country has a bigger pay gap between male and female workers?
2. Where would you live? How do you decide? What else could influence your decision?
3. How many more hours does a woman have to work to earn the same as a man who has worked 100 hours in both, Romania and UK?
4. What would be your loss, as a female worker, in each country after 40 years if you worked 40 hours a week, 48 weeks a year?
5. Why do you think this is the case? What can we do to tackle this problem?

Data from February 2020: https://ec.europa.eu/eurostat/statistics-explained/index.php/Gender_pay_gap_statistics

The task was designed for a Year 7 class but could have a wider applicability. As the students had just finished studying the concept of reverse fractions, the initial part of the task was constructed to allow them to apply the acquired skills in a problem-solving situation that involves working with real data around the issue of gender pay gap. So far, the task proposes to introduce the students to the data and help them make sense of it using the mathematical skills developed, for which I would recommend using bar modelling.

Further, the task intends to deepen pupils' understanding of the meaning of the data and the results obtained in the context presented through purposeful questioning and offering them a space for reflections. To support this, the format of comparing/contrasting was chosen as it engages comparative thinking (Silver, 2020), gives the results more meaning and leads to further analyses. The UK and Romania were selected for this investigation due to their differences in the level of economic development, the average income and the gender pay gap, which recorded an unexpected result in the context of the other two variables. The questions that follow aim to support the pupils in uncovering these discrepancies and advance their critical thinking and reasoning through mathematical analysis. However, their intended purpose goes further, as they are meant to raise concerns as to why this is the case and what can be done to improve the situation. This seeks to be a springboard for conversations and actions that go beyond the classroom.

Unfortunately, I could not carry out the task with my students due to the outbreak of Coronavirus which led to school closures. If the task had been deployed as planned a crucial objective for its implementation would have been to support the students in understanding and developing the skills required in dealing with global challenges. Thus, not only would I have encouraged the students to be inquisitive and critical in their investigation, but most importantly, collaboration and communication would have been strongly supported, as in my opinion, it is through sharing ideas and views that one discovers new perspectives that broaden one's own.

As this is an area of great importance for me, I would like to believe and hope that the students' response towards it would have been positive and they would have felt motivated to continue informing themselves about the issue and take further actions. I am aware that this might not always be the case. However, since I believe that an important aspect of teaching is to create an open space in which students can express themselves and form their own views and conclusions, my aim would have been to support them in developing a personal and informed opinion based on mathematical arguments.

Melting ice - Jürg Läderach

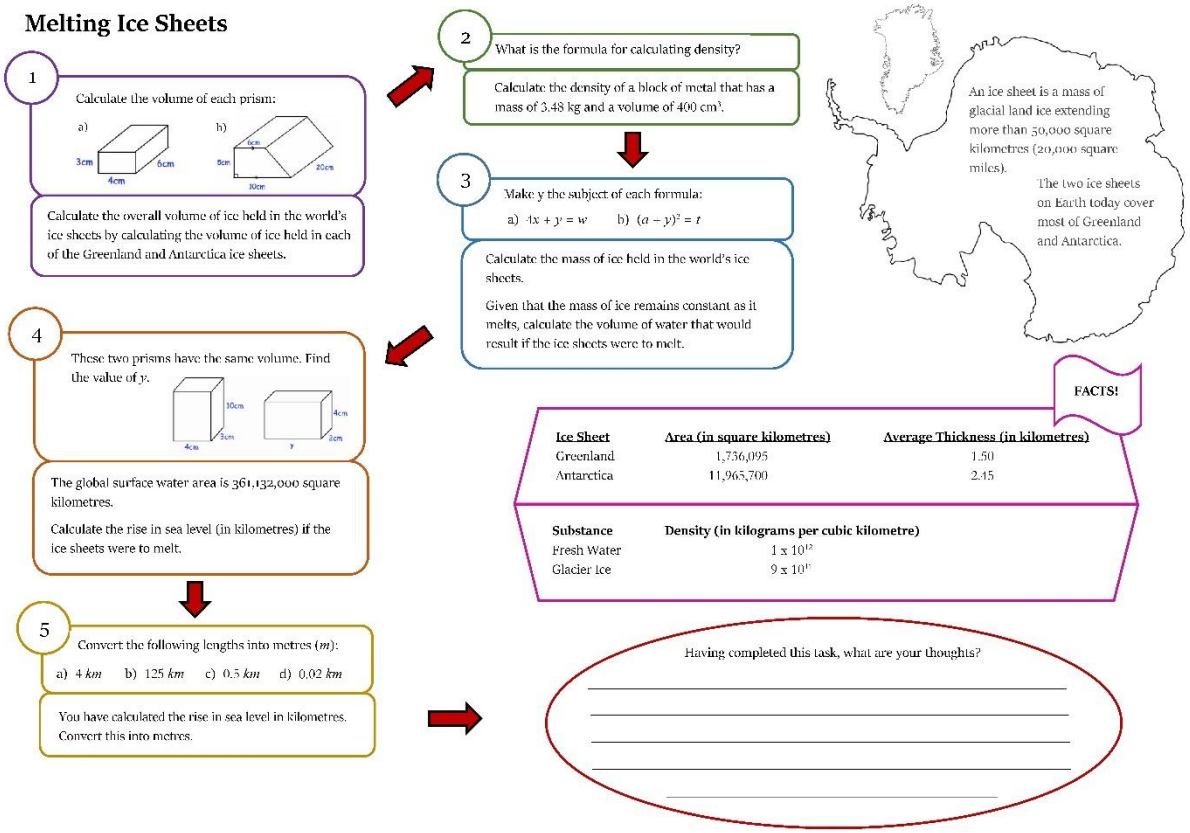
Related content: Area, Volumes of Prisms, Density

Bushnell's (2018) task on melting ice sheets is an approach to help students think about the effects of global warming by modelling ice sheets as prisms. The worksheet guides the students from length conversions over calculating the volume and density of a prism to the rise in sea level that would result from the ice sheets of Greenland and Antarctica melting

given the modelling assumptions made. At the end of the task, there is an opportunity for students to reflect on the tasks with a prompt for them to write down their thoughts.

Before the task, I would collect estimates for the rise in sea level if all the ice of Greenland and Antarctica were to melt completely. Then, I would introduce the task as a partner or group activity as this would allow for the students to talk about the modelling assumptions while they work on the problems. I believe a potential strength of this activity lies in it enabling a discussion about the value of approximations and estimations in addressing a global challenge. We might ask: What level of accuracy is required to model this problem? What considerations do we to take into account for our estimates and our calculations? At the end of the task, comparing our estimates with the results from the calculations could lead to a conversation on what those numbers trigger in ourselves (e.g. are we surprised or sceptical about the figures we obtained?) and what they could mean for us as a population.

In a next step, the task could lead on to fermi questions: The vast amount of ice and meltwater is hard if not impossible to visualise. Newspapers and TV outlets like to illustrate large numbers by comparing them to everyday objects such as bathtubs or the Elizabeth Tower[1]. Based on this idea, students could investigate their own fermi questions by choosing their own objects. This could lead to a discussion over whether the comparisons used by media outlets help the audience 'see' those large numbers or whether they are merely a device to keep the audience interested.



(Bushnell, 2018)

[1] https://www.bbc.co.uk/sport/get-inspired/47977024

Overall, Bushnell's (2018) activity is very versatile. Depending the students' prior knowledge on calculating volumes, I might offer more or less scaffolding in the form of teacher inputs between the tasks or on the worksheet itself. For certain groups, it might also be valuable to illustrate the rise in sea level by practically modelling it with water and a glass container to see the link between the area over which the water is distributed and the resulting water level.

Covid-19 - Izaak James

Related content: Loci; averages (Large Data); simplifying and comparing fractions; fractions and percentages; presenting data (and interpreting charts) bar charts, line graphs, heat maps; probability; extrapolation.

In February and March 2020, I began designing a task applying loci to a global challenge. This particular instance was an imaginary airborne disease, which had a contagious radius of 2m. The task was to illustrate contagious zones using 2D projections of individuals moving in a given space. First using a single static person, then moving along a linear path, then a curved path. Next, more and more individuals move together, and their paths begin to overlap. Could we use the geometric tools we had learned to identify potential transmissions? Can we start to think of methods to reduce the instances of transmission? What does that look like on our projection? These were contentious questions and ones I really wanted my students to be thinking about, so I posed them to them.

There was a beautiful irony surrounding this task: As part of our PGCE course, I had to make a task designed around global challenge, during an acute global challenge. There was chatter amongst us trainee teachers about what our global challenge should be, and the consensus appeared to me to be "Don't talk about COVID-19!".

Well, I just could not help myself. There were a couple of reasons that spoke for choosing it. Firstly, it was extremely accessible. How could one not comprehend what I was talking about? Secondly, there is a desire to develop an immediate sense of the usefulness of the concepts that we were teaching and learning at KS3.

Potentially by using these mathematical tools, the students might be able to get a greater understanding of some of the problems that they were increasingly encountering on a daily basis – maybe even in a way adults might not recognise. For example, a queue which is 2m spaced was swiftly becoming the norm. At a certain length, the queue needs to snake round. What good is it if each parallel queue is not 2m from the next? I wanted my students to know this and to question everything they were seeing.

There was a nice opportunity to extend in many ways. We could start using ICT resources manipulate the scenarios we were discussing; to see people moving and see the loci moving with them. Beyond that, there were some more practical extensions. One idea was to associate a probability of infection to each potential transmission, then consider factors that

change this probability: things like wearing a mask and washing hands thoroughly. I want the students to understand the mathematical effects of all these things we were being asked to do. We could have kept pushing, trying to break down each measure, looking at trends, examining exponential growth, big data analysis for mortality rates, extrapolation to estimate current infection totals and so on.

To my mind, there was this immense resource everyone was experiencing all at once. A deeply mathematical problem with a real emotional connection that we could use to help us comprehend and retain the associated mathematics.

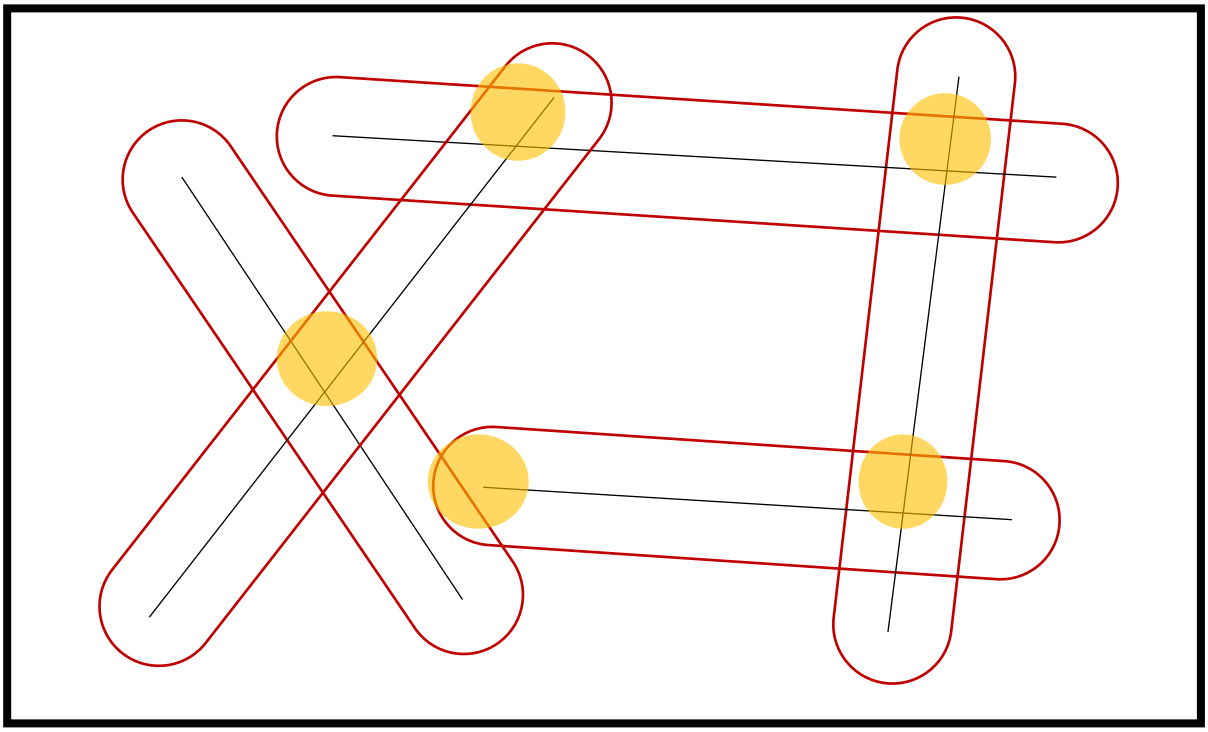


Figure 1 - An example of 5 linear paths. The task here would be to draw five random straight paths, construct their associated loci and then assess potential transmission points (highlighted in Yellow).

Conclusion – Julian Brown, Alf Coles, Tracy Helliwell

In the final task write up, Izaak mentions the issue of emotional connections with deeply mathematical problems. And we observe a theme of emotional connection across the tasks offered in this article and in Part One (Brown et al., 2021). One thing we feel we have learnt from the work reported here is that there is a power in offering students tasks related to issues we care about as teachers; and, we feel we have evidence, from Part One, that students pick up on and respond positively to our own enthusiasms and passions.

We are conscious that the tasks offered across this article and Part One are “one offs” and that there is a danger of tokenism in this respect – mirrored with regard to the limited space we give to global issues during the PGCE course on which we teach. And yet, we feel that we need to start somewhere. The words “investigate” and “explore” have recurred through the two articles and we view developments in *how* we teach to be necessary alongside changes in *what* we teach. We cannot know the challenges that will face students when they leave

school and so the details of the content of our teaching are perhaps less important than the approaches or attitudes to learning which students develop. For instance, if our students leave our classrooms believing that mathematics is a subject in which they can ask questions, then we hope such questioning is an attitude they will take with them into other parts of their life. If we can create spaces in our classrooms where students can sometimes work on their own questions and pursue their own lines of inquiry, then we hope we might inspire them into continuing such explorations into the issues and challenges that matter to them.

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