Exploring teachers' use of time gained due to the use of a flipped classroom approach in mathematics

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In response to teachers' complaints about an overcrowded curriculum, FMSPW initiated a research project into the Flipped Classroom Approach (FCA) in two phases. We have already reported on teachers' and students' experiences of introducing and using the FCA (Phase 1) at previous conferences (Joubert, Oakes, & Lyakhova, 2019; Oakes, Davies, Joubert, & Lyakhova, 2018). In this second phase of our research we are focusing on the teaching and learning of mathematics, looking at how teachers are using the time gained and teachers' and students' perceptions of improved mathematical learning.

Flipped classroom, resources, pedagogy, depth, connection

Outline of the problem

In 2015, the Welsh examination board (WJEC) introduced new specifications for A-level mathematics and Further Mathematics. The Further Mathematics Support Programme in Wales (FMSPW) worked with a group of teachers in Wales to construct a scheme of work to support understanding of the new specifications. The idea behind this scheme of work was that it would help teachers to teach mathematics rather than teaching how to pass the examination, focusing on building connections and developing deep conceptual knowledge. However, many teachers suggested that, although they would like to teach in this way, there was not enough time to do so.

In response, the FMSPW suggested they might try a new teaching approach in which students are introduced to the content, or the 'chalk and talk' part of the lesson via video at home, which would mean that there would be more class time for teaching in a connected and deep way. This approach is usually referred to as the 'flipped classroom approach'.

We are interested in whether and how this approach of freeing up time does in fact lead to the sort of teaching described above.

Flipped classroom research

First, teachers considering flipping their classroom should focus on in-class experiences (Baepler, Walker, & Driessen, 2014)). According to a study at the university level focused on reducing seat time and increasing depth of knowledge for students enrolling in large lecture chemistry classes, researchers stated that their success in achieving their research goals was the result of focusing less on quantity of time in the classroom and more on quality of interactions and activities that students engaged in during the class time.

This suggests that teachers should provide more opportunities for peer interactions, discussion, and feedback (Crews & Butterfield, 2014). Strohmyer puts it thus,

> Effective and sustainable flipped learning environments seek to engage students in lower-order thinking tasks through assigned readings, screencasts, and basic practice items outside of the classroom, while classroom time is used to expand students toward higher order thinking tasks that may include working collaboratively to solve life-like problems, exploring concepts in greater depth based on teacher-posed challenges or personal interests, and the development of authentic assessments and presentation tasks. (Strohmyer, 2016, p. 61)

On the question of instructional design, Strohmyer says,

> Some types of knowledge, such as basic facts and foundational information can be learned best through exposure and repetition (Geary, 2007; 2008). Others required more meaningful learning experiences that root more abstract or new information to mastery level learning. These attributes have to be considered when designing instruction in order to make decisions on what students can learn through exposure and repetition and what requires deeper experience and interaction. (Strohmyer, 2016, p. 31).

We have found that the FCA has released time for exploring more advanced aspects of topics (Oakes et al., 2018). Further, we found evidence of increased collaboration, and generally mentioned that when tackling new questions in class they engaged in a process of trying it on their own, then on their table and only then involving the teacher.

De Araujo, Otten, & Birisci report the attractions of the FCA to a teacher: “I liked the idea of having time to really deepen the understanding of math and make the real world connections that you typically do not get to do.” (de Araujo, Otten, & Birisci, 2017, p. 63).

What we did

In a professional development meeting held in North Wales in March 2018, we introduced the idea of using the flipped classroom approach (FCA). A number of schools in the area expressed an interest, and, following this, six teachers participated in initial research meetings in July 2018 and September 2018. Four teachers eventually took part in the research.

In Phase 1 we researched teachers’ and students’ experience of introducing and using the FCA. In this second phase of our research we continued in North Wales, with two secondary teachers (HH & AD) with classes in Mathematics and Further Mathematics A-level respectively, which took part in our initial research. During the project we worked collaboratively with teachers to design two ‘special’ lessons each intended to develop deeper levels of mathematical understanding for students. In brief the lessons were for Teacher HH: 1) Statistics: connections, GCSE to Further Mathematics and 2) Vectors: generalising intersections of lines (both Y12 Further Mathematics). For teacher AD, the lessons were: 1) Binomial Ranges: words to inequalities and 2) Binomial & Poisson Tarsias: a large amount of practice in groups (both Y12 Mathematics.) The researchers observed the lessons, interviewed teachers, surveyed students using an online questionnaire and interviewed a sample of students.

Data was gathered between January and May 2019 and consisted of lesson observations and interviews with teachers and students. For this paper, the data was analysed to answer questions about how teachers use the time released **productively** to achieve the desired benefits of teaching for greater depth and understanding?’ The approach adopted was a thematic approach informed by the literature.

Findings

This section reports on the findings from the research by considering the ‘special’ lesson in turn from the student and teacher perspectives.

For teacher HH, the lesson on Statistical connections involved sorting cards into categories within a learning phase (GCSE, A-level Mathematics and A-level Further Mathematics) and then identifying connections within and between each phase. The final output of this activity is shown in Figure 1.

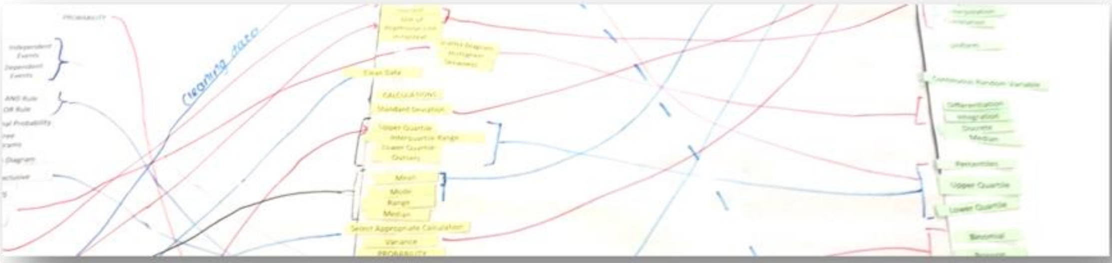


Figure 1: Connections in statistics

In their interviews some time after the lesson, students explained that it was a different type of activity, saying that usually they do the work but that this activity provided an understanding of what had been covered in the last few years and how it has all come together. One student discussed how she had made different links to other students and had justified her thinking to the others, implying perhaps that this had also been important for her own learning.

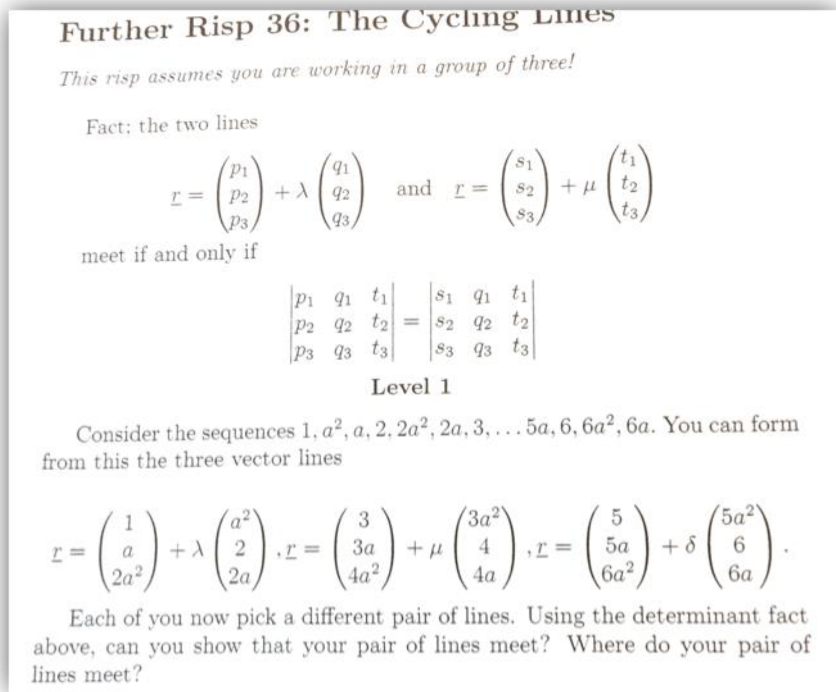
> We had all the topics from Stats from GCSE to A-level to Further Maths. Basically, we just had to join up where the topics related to previous years to the latest topics. I thought it was really interesting because it was easy to break stuff down and then you could see just see that it was less daunting because you could see that it was going from that to that to that and you could do that bit…Some people link stuff differently from the way you would…. I would link certain stuff and they would say “really”, and I would say yeah because they go together. (HH, S2)

The teacher was clear that the purpose of the lesson was to develop a connected and deeper understanding of statistical topics, saying that the focus of the activity was on connections rather than knowledge, and that students had been required to interpret the sub-topics and look for connections.

She also identified an added benefit for their mathematics learning in general in that the students were…:

> … now looking for connections with things in other things as well. So they would be, when we’re discussing other topics, they’ll be going, “well is that like this” or, “that’s like when we did this.” (HH)

The vectors activity was more abstract than the usual vector work, involving more advanced notation and abstraction. Figure 2 is taken from the worksheet the students were given and provides an indication of the task.



Further Risp 36: The Cycling Lines

This risp assumes you are working in a group of three!

Fact: the two lines

$$\underline{r} = \begin{pmatrix} p_1 \\ p_2 \\ p_3 \end{pmatrix} + \lambda \begin{pmatrix} q_1 \\ q_2 \\ q_3 \end{pmatrix} \quad \text{and} \quad \underline{r} = \begin{pmatrix} s_1 \\ s_2 \\ s_3 \end{pmatrix} + \mu \begin{pmatrix} t_1 \\ t_2 \\ t_3 \end{pmatrix}$$

meet if and only if

$$\begin{vmatrix} p_1 & q_1 & t_1 \\ p_2 & q_2 & t_2 \\ p_3 & q_3 & t_3 \end{vmatrix} = \begin{vmatrix} s_1 & q_1 & t_1 \\ s_2 & q_2 & t_2 \\ s_3 & q_3 & t_3 \end{vmatrix}$$

Level 1

Consider the sequences $1, a^2, a, 2, 2a^2, 2a, 3, \ldots 5a, 6, 6a^2, 6a$. You can form from this the three vector lines

$$\underline{r} = \begin{pmatrix} 1 \\ a \\ 2a^2 \end{pmatrix} + \lambda \begin{pmatrix} a^2 \\ 2 \\ 2a \end{pmatrix}, \underline{r} = \begin{pmatrix} 3 \\ 3a \\ 4a^2 \end{pmatrix} + \mu \begin{pmatrix} 3a^2 \\ 4 \\ 4a \end{pmatrix}, \underline{r} = \begin{pmatrix} 5 \\ 5a \\ 6a^2 \end{pmatrix} + \delta \begin{pmatrix} 5a^2 \\ 6 \\ 6a \end{pmatrix}.$$

Each of you now pick a different pair of lines. Using the determinant fact above, can you show that your pair of lines meet? Where do your pair of lines meet?

Figure 2: Vectors RISP: a taste of a higher level abstraction

The perceived benefit of this activity on the part of students was that teamwork led to a sharing of understanding and skills. One student reported:

> We all had to work them out separately and then kind of link them together for the end question. And I think that one was interesting also because you find out on your own but you also rely on everyone else. It was more of a team effort… you learn someone else's tricks. (HH, S2)

The teachers view was:

> That's an extension depth. So it's special in that way. It's beyond the spec. but hopefully will give them greater understanding. (HH)

For teacher AD, we will consider the Binomial and Poisson activities together. The first activity was a card matching exercise designed to hone students' understanding of ranges of values in discrete distributions. See Figure 3 for work in progress.

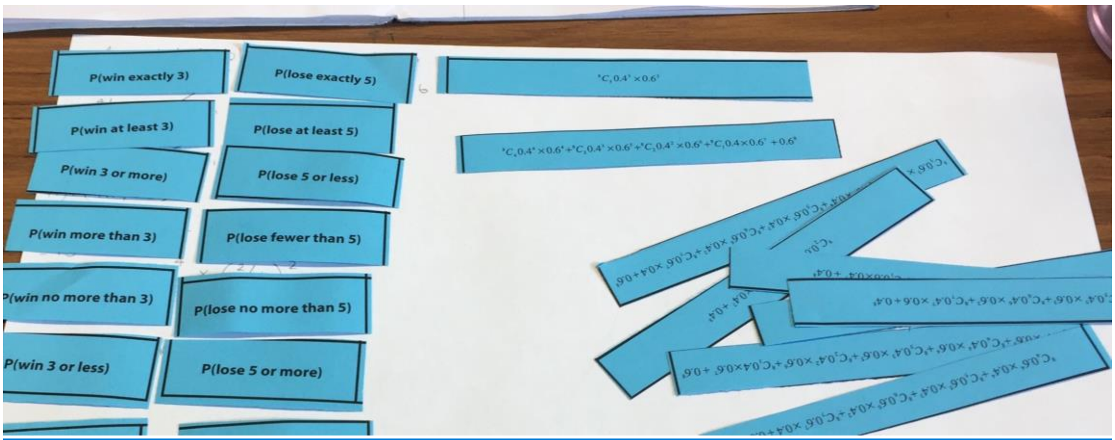


Figure 3: Binomial Ranges: Emphasising language and understanding the structure of formulae

The second was a Tarsia matching of Binomial and Poisson probabilities which then formed a pleasing large hexagon of results (see Figure 4, again for work in progress). Both tasks were done in teams of two to six students.

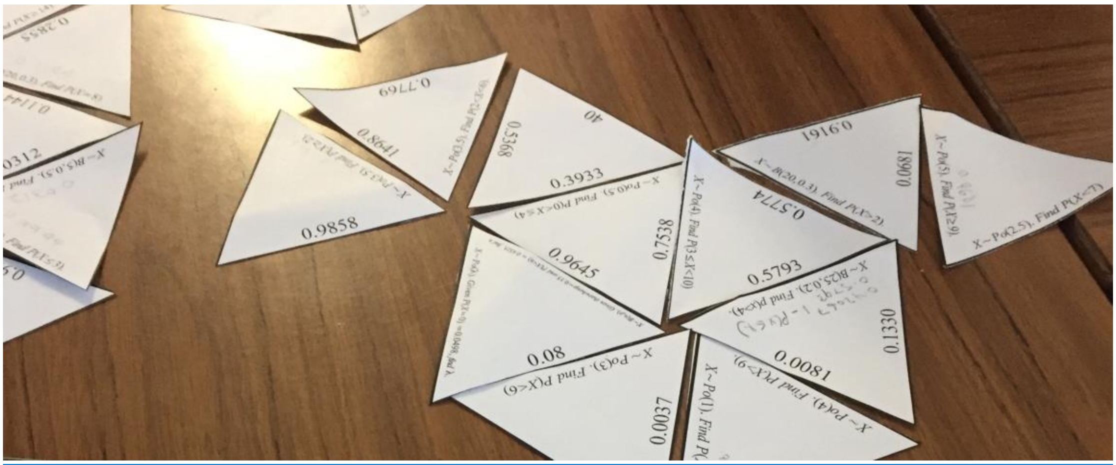


Figure 4: Binomial & Poisson Tarsias: intense practice and availability of answers

One student was clear on the benefits of working together on the tasks and concluded that following these exercises, her class was largely on top of the topic:

> I feel like with this way, we, by talking about it, and doing activities like this, when it comes to past papers we can just get on with it and there's not much questions asked on how to do it because we've already done tasks (AD, S1)

Comments from the student survey included: “It helped me understand the terminology for statistics,” “I could understand the topic a lot better”, “…deeper understanding of distribution” “… finally completely understand the binomial work.” Some full quotes of interest mentioned particular benefits of the activities:

> I really enjoyed trying to get an end product but also practising similar questions so the method was secure by the end.

> Knowing if I went wrong because there were only certain answers that could be achieved.

> Yes, I do remember this lesson and I think what stood out for me was that it was a task we were given that directly involved teamwork along with problem solving, that and that it differed from the usual lessons because we already had the answers and our task was to calculate which square matched up with what answer.

The teacher considered the value of the activities in terms of working in teams as well as affording intense practice, explaining that, although the activity involved examination-type questions, the novel format was appealing to the students and by the end of it they had completed about thirty practice questions.

He said he thought that the lessons led to greater depth of understanding and also commented on the time aspect, explaining that with the class time released by using the flipped approach, he had been able to “do extra little lessons”.

Conclusion

The research suggested that there was general agreement (teachers and students) that the ‘special’ lessons were different and memorable. Teachers mentioned the benefits of forming connections across topics, deliberately more advanced work, varied and intense practice through group work. To this extent, therefore, we can conclude that lessons specifically designed to develop deeper understanding can be used successfully within a FCA.

We also should consider these lessons within overall course planning. In Phase 1 of our research, we have seen opportunities for greater depth of understanding through the increased classroom time for teachers to directly support students; in Phase 2 we have seen activities deliberately designed towards this end to be of benefit.

The next steps in developing this research may involve planning lesson sequences that embed the 'special' lessons we have considered here so that, in a sense, we remove the specialness. It would then be interesting to research whether, as teachers become experienced with the FCA, these types of lessons become naturally part of their planning.

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