Exploring teachers' and students' responses to the use of a Flipped Classroom teaching approach in mathematics

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Many teachers of mathematics claim that they would like to teach in ways that promote understanding but that, because the curriculum is so crowded, they do not have time. One approach to freeing up time is known as the 'Flipped Classroom' approach (FCA), in which students learn new content at home, using resources such as videos and written explanations. This allows teachers to use time in the classroom to deepen understanding. This research is set in North Wales, and involves four teachers with A-level and Further Maths classes. Teachers inducted students into the 'Flipped Classroom' approach and followed this for their mathematics lessons for eight weeks. We investigated teachers' experience of: pre-lesson resource production; effective pedagogic approaches in the lesson; differences from non-FCA pedagogic approach, materials etc.; what they might do differently another time; students' responses. We also investigated students' experiences of the flipped classroom approach.

Flipped classroom, resources, pedagogy, depth, connection

Outline of the problem

FMSP Wales wrote a resourced Scheme of Work (SoW) for the new WJEC Mathematics and Further Mathematics A-levels, underpinned by the philosophy that it is important to: teach mathematics rather than teaching to the exam; build with connection in mind; focus on mastery; put proof at the heart of the syllabus.

Following this we offered Continuing Professional Development (CPD) about our SoW in December across North Wales. At these events many teachers said that their biggest problem was lack of time to deliver the specifications in a connected, deep way.

In an effort to free up valuable class time, we considered taking a 'flipped' approach, in which students are introduced to new material usually through the medium of video, although other ways of introducing new content are possible.

> In flipped learning, delivery of content is undertaken via video instruction accessed online. Class time is focused on supporting students in working out the problems themselves.(Straw, Quinlan, Harland, & Walker, 2015, p. 6)

While ultimately we are interested in whether and how this approach does in fact lead to the sort of teaching described above, in the first instance we wanted to evaluate how well the approach worked for both teachers and students. This is the question addressed in this paper.

Flipped classroom research

The idea of introducing students to content prior to the lesson is not a new idea, as Herreid and Schiller explain: 'Teachers have forever struggled to get students to study on their own, either ahead of time or as homework; that is when the real learning happens, not when the teacher is lecturing, droning on and on.'(2013, p. 65). What is relatively new, however, is a) the use of video to present content and b) the term 'flipped' to describe the approach. Over the last 15 to 20 years, a body of research related to the use of a flipped approach has developed.

In the main, research in this area has been conducted in higher or further education contexts, in a range of subject areas. For example, the review of recent literature by Uzunboylu and Karagozlu (2015), drew on research set entirely in the higher education sector, and in various subject areas, including health, micro-economics, mathematics and chemistry. There are, however, some studies set in schools (e.g. Straw et al., 2015).

One major concern of the research appears to be to develop an understanding of 'what works' both in terms of the setting up of the learning from the teacher's perspective (e.g. Kim, Kim, Khera, & Getman, 2014; Lo, Hew, & Chen, 2017) and the design of the resources. Generally, and unsurprisingly, it is agreed that 'it's not the instructional videos on their own, but how they are integrated into an overall approach, that makes the difference.'(Tucker, 2012, p. 82).

The research literature also identifies benefits of using a flipped approach. These include freeing up class time, which has knock-on effects of providing more time for problem solving in class, more interaction between the teacher and the students, and between students and students, which results in more mathematical discussion in class and better peer learning (E Silva, 2014; Jungic, Kaur, Mulholland, & Xin, 2105; Lo et al., 2017). Further, the videos or other materials are available at all times, which means that students can access them at any time (Ziegelmeier & Topaz, 2015) including using them for revision (Grypp & Luebeck, 2015) and helping them to prepare for class (Kraut, 2015).

On the other hand, it is clear from the literature that there are some challenges associated with the use of technologies when using the flipped classroom approach. For example, students are sometimes reluctant to take responsibility (Eager, Peirce, & Barlow, 2014), and they report that they prefer being able to ask questions as they go along rather than wait for the class (Anderson & Brennan, 2015). For teachers, there are challenges in getting the materials prepared on time, although normally after the initial start-up effort, it becomes easier (Adams & Dove, 2016).

What we did

We offered further CPD in North Wales in March 2018, briefly discussing the flipped classroom approach (FCA) and asking if anyone would like to participate in trials. Several schools in North Wales expressed an interest. Following this, a number of interested teachers attended meetings in July and September 2018. The first meeting focused on a deeper look at the theory of and existing research into the FCA. The second meeting addressed practicalities of the FCA and the logistics of our research.

Four teachers and their research classes, some A-level and some further mathematics, chose to take part in the research during October and November 2018. Researchers observed two lessons, about a month apart, and interviewed the teachers. Some students were also interviewed on an ad-hoc basis.

A case study from north Wales (AD)

Andy Davies, one of the authors of this paper, is Head of Mathematics at Ysgol Eirias, a large North Wales Secondary School with sixth form college. Within the mathematics faculty there are two teaching groups in both Year 12 and 13 with approximately 20 students in each class. Andy teaches the WJEC A2 Mathematics Unit 2 and 4 modules respectively to both groups. To cut down repetitive teaching Andy joined the project to trial the flipped learning concept with his students.

All videos were created using an Apple pencil, the application "Notability" and the screen record function on the iPad. Videos were uploaded direct to his Youtube channel to which the students had subscribed: they received a notification to their devices when a video had been uploaded.

The videos were between three and four minutes in length. There was a common acceptance amongst students in initial discussions with Andy that a video longer than this would take a long time to review and translate into note form. Videos for each topic were uploaded approximately a week in advance of the lesson to give students time to watch and make notes. Students were expected to watch the videos and make notes based on their content. Students mainly opted for taking detailed notes using colour and highlighting key points. Other students either took screenshots or used the Notability application themselves to make notes on their iPads.

The first lesson of a new topic always started with a short review exercise. Questions were based solely on the content of the videos: this allowed Andy to check whether students had actually watched the videos and understood the content. Students were allowed to refer to their notes if needed for support. Initially in a very small number of cases students had not reviewed the videos in enough depth.

Once the review sheet was completed the students started immediately on questions of increasing difficulty. As the project continued two things became evident. Firstly, the rate at which the students were moving through the curriculum had accelerated in comparison to the previous year. Secondly the depth and level of discussion in the class had also increased as time released from direct instruction at the board was spent by working on questions. Andy noticed students seemed more confident on entering the lesson at the beginning of a new topic; it seemed they liked arriving at a lesson having already had time to absorb the main concepts.

As the project continued all students were actively reviewing videos on a regular basis. Andy was able to monitor views on his videos from the administration section of his Youtube account. Time was also built in for short Q&A sessions during the lesson as questions cropped up. This was included following the first observation when it was noted by some students that they felt like they could not ask specific questions in class. During the lesson students would then be encouraged to ask questions they had from watching the videos and any common misconceptions were discussed as a whole class. Andy would also ask questions that would test the depth of the students' understanding as the lesson progressed. An important aspect of the lesson was that videos were never played in the classroom. There would always be a danger if this happened that students would not then do any review work at home.

Findings

This section reports on the findings from the research in two parts: findings from the perspective of the teacher and findings from the perspective of students. These findings follow the first round of observations and interviews.

Teachers identified several advantages and disadvantages. These can be considered under three categories: preparation, homework and lessons. These categories are used to structure the discussion below.

In terms of preparation, all participants reported that making the videos was time consuming. In some cases they encountered technical difficulties, but by the end of the two-month observation period these had been resolved. It seems that the most time-consuming aspect of making the videos was the preparation, which required the teachers to think in detail about exactly what they wanted to say and do in each video.

> I'm having to think more about what I'm going to do and to find time to actually make those videos but making the videos takes quite a long time because you've got to think about exactly what you want to say and exactly what you want to do and what the effect's going to be in the lesson." (AB Interview 1)

Data related to homework reveals that teachers found very few problems with students completing the video homework, including the taking of notes. Where there were problems, it seems to be the student's attitude to homework, rather than the fact that it is via video,

> Two boys said they watched video and understood examples but they hadn't been able to do questions on their own – their problem was that they couldn't complete the square because they hadn't watched the videos from last week and they came to last week's lesson not being able to do it and hadn't done anything to address this in the intervening time, like go back and watch the other video … You would have a situation last year [non-flipped classroom], they would look at how to complete the square and have some homework on it where they needed to practise it and they wouldn't do it. So it's the same thing. GS, interview 1)

In terms of lesson changes, participants have commented on lessons feeling different. One teacher mentioned that he missed the 'interactivity of delivering to them', saying that, using this FCA, he could not gauge their understanding as they went along.

Teachers have noted that there is more student discussion:

> …they are talking a lot more than my Year 12s did last year. …. I'm hoping it's because I'm giving them harder work in the lesson and therefore they're being forced to discuss it with each other. (HH, interview 1)

The FCA has also led to students thinking in more depth. For example, in a lesson on inverse hyperbolic functions, the teacher said that he would have done the same examples but would have taken more of a teacher-led approach. Also time has been released for more advanced aspects of topics:

> Before I would have spent the first lesson on how to complete the square… the second lesson would have been the harder ones with a little bit at the end about the maximum and minimum values… it did mean that this time we spent a lot more time working on maximum and minimum values (GS, interview 1)

Students also identified several advantages and disadvantages: We can consider these under homework changes and lesson changes, with these categories used to structure the discussion below.

Observations (homework): Students like the approach generally. Students from all classes mentioned liking taking notes in their own time and working through the videos at their own speed. They also mentioned the benefit of being able to pause videos to take notes; the one to one nature of the videos; working in quietness; the clear instructions in the videos; knowing exactly what to do for homework.

A common disadvantage mentioned was not being able to ask questions: "It works well for some topics but not so well for others because you want to ask

questions as you go along" (student observation, AD1.) Connected to this, one student mentioned liking the FCA for particular learning; she liked the videos for an introduction to a topic, for recapping and for proofs.

In one class some students mentioned difficulties with 'next day' video homework. Teachers generally try to avoid next day homework but for this class the timetable made this problematic. Most students had found workarounds but for a few (including those with evening jobs) this was a challenge.

Technical problems affected some students: videos taking a long time to load. One student said that "file sizes meant that I had to use Wi-Fi or it would eat my data" (student observation, GS1.) There were one or two more specific access difficulties. One student had moved from another school and had not yet had his Hwb account (from which the videos are accessed) transferred. He had worked round this by "finding equivalent videos on YouTube" (student observation, GS1.)

Observations (lessons): Again students were largely positive. They mentioned liking the fact that everyone is at the same place at the start of the lesson and having more time to think. A number of students mentioned tackling harder questions in class and that they can get help with these harder questions in class.

There were few complaints about the lessons. One student mentioned a drawback which is that she likes to tackle questions with various resources to hand such as books and Internet that she doesn't have in class.

In conclusion we found that teachers and students are generally comfortable with the FCA. We found perceptions of deeper understanding and better teaching. There are questions about sustainability with regard to video production and teachers need to consider that if introducing the FCA in Y12 that students are coping with two big changes at once – FCA and the jump into sixth form.

Conclusion

Our research shows, tentatively, that time is released for greater understanding and more depth in A-level Mathematics teaching by adopting a FCA. It identifies some classroom opportunities as well as problems that need to be considered by teachers considering the FCA. Generally the findings are in line with the literature. In terms of policy, there are implications at the school level in terms of support for teachers implementing an FCA approach and at the wider local and national level in terms of shared resource production and CPD provision.

Phase 2 of the research is planned and will focus on the teaching and learning of mathematics, working on the assumption that the teachers and students are comfortable with using the FCA. Ultimately, it is intended to develop good practice guidance in this area (both in terms of flipped resources and classroom pedagogy).

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