Evidence for Excellence in Education

FLIPPED LEARNING

RESEARCH REPORT

National Foundation for Educational Research (NFER) and Nesta

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Contents

Main messages

This small-scale study, undertaken by the National Foundation for Educational Research (NFER) and Nesta, revealed both the benefits and challenges of implementing a flipped learning approach to mathematics teaching. It explored the benefits and the practical considerations of using video resources in implementing a new approach to teaching and learning in schools.

Flipped learning was used to relocate direct instruction of new concepts to homework time and allocate lesson time to active learning activities. Such activities included pupils practising and applying mathematical knowledge with coaching support provided by the teacher. Where flipped learning was reported to have worked effectively, case-study interviewees said it had had a beneficial effect on student learning. The approach encouraged students to take responsibility for their learning, to learn at their own pace, to deepen their knowledge and understanding and to make faster progress than would otherwise have been the case.

Enabling factors included access to appropriate technology, online resources which were appropriate for the age and ability level of students, a culture of homework participation and teachers' openness to the approach.

Participating schools implemented flipped learning in different ways. This reflected teachers' and students' preferences, as well as practical considerations. These approaches included teachers using online videos and exercises at home, during school time but outside of normal lessons, (e.g. as a managed homework session), and as a carousel of activities within lessons. Some students found the use of video technology and online exercises engaging. Others preferred to be able to interact with teachers face-to-face and to ask questions.

Teachers in the study used various existing instructional video resources to implement a flipped learning approach. They selected resources that aligned with the curriculum, their own approach to teaching, and that were appropriate for their students' age range and abilities. Some teachers welcomed online resources that significantly stretched and challenged their students, others preferred resources that more heavily scaffolded and guided student learning. Brief exercises and note-taking linked to the videos encouraged active engagement.

Most of the teachers in the study who piloted a flipped learning approach reported that they would continue to use the approach as part of a varied repertoire of teaching strategies. Some teachers planned to embed the use of flipped learning with particular curriculum topics and to extend its use amongst teachers in the mathematics department. Others planned to adopt aspects of a flipped learning approach, such as the use of online video resources, and integrate this into a more traditional model of teaching.

Our findings suggest that there may be scope for teachers to further refine and enhance models of flipped learning beyond those developed as part of this short pilot study. This could include more use of: student-centred and peer-teaching activities; research and problem-solving; extended discussion; and assessment and feedback informed by performance on online activities.

Detailed and specific guides to implementing flipped learning accompany this research report.

Executive summary

Flipped learning

Flipped learning involves the use of digital technology, such as video, to provide direct instruction on new concepts outside of the classroom. Students come to lessons already having a preliminary understanding of the topic, freeing up class time for the teacher to focus on other beneficial learning activities.

About this study

This small-scale qualitative study, undertaken by the National Foundation for Educational Research (NFER) and Nesta, set out to explore how flipped learning can be delivered in UK classrooms, what effect a flipped learning approach has on teaching and learning in mathematics, and to provide illustrative examples of the benefits and challenges of different approaches to flipped learning.

The study took place in the academic year 2014-15 in nine case-study schools (three secondary schools and one middle school in England, and five high schools in Scotland). A flipped learning approach was piloted with a Key Stage 3/Secondary 1-3 class in each school with a topic of mathematics work lasting around half a school term (4-6 weeks). A comparable class of the same age group was taught mathematics using a traditional approach to provide a basis for comparison.

Teachers were asked to use Khan Academy mathematics resources in their delivery of flipped learning. They were provided with a guide to implementing the approach and documents which mapped the Khan Academy resources to the relevant curricula. The Khan Academy website provides instructional mathematics videos, exercises and reporting functions on students' performance. In practice, some schools used alternative digital resources which they decided were more appropriate for their students.

Teachers and students provided their reflections on their experiences in interviews, focus groups and via questionnaires. Researchers also undertook lesson observations of both flipped learning classes and lessons taught using more traditional approaches.

Schools' implementation of flipped learning

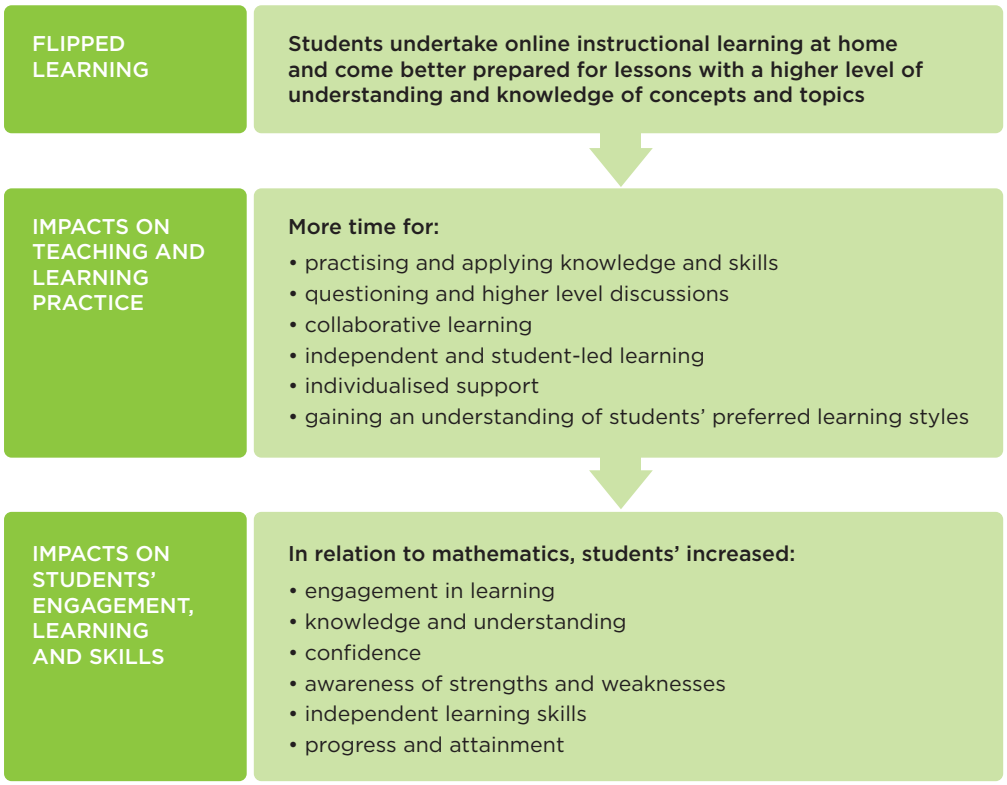
Most of the case-study schools implemented flipped learning as envisaged, with students undertaking online instructional learning for homework prior to class lessons. Some schools modified this approach and also provided access to the videos as part of lesson activities.

A number of features evident in the nine case-study schools distinguish a flipped learning approach from more traditional teaching approaches:

- Homework time is typically used to deliver new content to prepare students for lessons, as opposed to being used for revision and consolidation.
- Greater use is made of online learning such as videos, presentations and exercises than offline learning such as textbooks and worksheets.
- Teachers spend more time in lessons coaching and facilitating learning and less time providing whole class instruction and demonstration.

The impacts of flipped learning

Where flipped learning was implemented more successfully, case-study interviewees reported it had resulted in a range of benefits for teaching and learning practice and for students' engagement, learning and skills. The diagram below provides an overview of the impacts reported.



Challenges to implementing flipped learning

Teachers reported encountering a number of challenges in implementing flipped learning. These related to:

- Access to technology.
- Identifying appropriate online resources.
- Students not participating in preliminary homework.
- Teachers' and/or students' preferences for face-to-face, as opposed to remote instruction.

In some cases, these challenges were overcome, resulting in the success of the approach. In others, particular challenges limited the impact achieved.

Conclusions and 'top tips' for schools

Teachers valued a flipped learning approach as part of a varied repertoire of pedagogical strategies. Most of the teachers in case-study schools were keen to continue using a flipped learning approach, either to introduce new content or to support revision and recapping of prior learning. Some intended to extend its use amongst teachers in the mathematics department. However, there were differences of opinion as to whether these activities should (and could) only take place outside of the classroom. For example, where teachers experienced challenges with learning taking place outside of lesson time (e.g. due to problems with home computer access and non-completion of homework), some regarded it as necessary to also provide online access to resources in the classroom. In some cases, teachers were keen to explore further the potential benefits of flipped learning for personalised, student-led and collaborative learning.

The study has revealed a number of **'top tips'** for teachers considering implementing flipped learning:

Access to technology

- Access to computers or mobile devices and Wi-Fi at home needs to be considered (and within school if students will also be accessing resources during school time). This may involve some consultation with students to gauge their home access. Consideration may need to be given to use of smart phones or the loan of laptops where students do not have access at home.

Identifying appropriate video/digital resources

- When choosing resources, it is important to check to what extent they match the curriculum and topic. Resources that provide teacher feedback on the activities that students have completed at home and how they have progressed (such as Khan Academy) provide useful feedback to draw on when planning lessons.
- The video and digital resources that are available can be used for both flipped learning and also for revision and recapping content that has already been taught. Material that is less scaffolded and more complex may be more suitable for revision and extension purposes.

Homework culture

- If the school does not have an embedded homework policy that results in a high level of engagement with homework, schools need to institute this before they embark on flipped learning. Otherwise, schools could consider approaches such as opening up access to computers during break or lunchtime, running a session in a computer suite facilitated by a non-specialist teacher or teaching assistant, or enabling students to use the online resources during lesson time. In addition, parents/carers can be involved to help facilitate the process and help ensure homework is completed.

Attitudes and capabilities of students

- The attainment level, maturity and ability to work independently of the student group should be considered. Teachers in the pilot schools tended to target more able students but this does not need to be the case. For students with more basic levels of understanding of concepts and less confidence in working independently, it will be important to consider how their learning is scaffolded to ensure that they are not put off by a lack of appropriate explanation and activities that are of too high a level.

- Where students are less confident and familiar with taking responsibility for their own learning outside of lessons, teachers can consider introducing them to the online resources first in class in a more supported and guided environment.
- In addition, teachers can consider drawing on the knowledge and skills of students who have completed the activities for homework by asking them to lead the start of the lesson or support their peers in pairs or groups.

Managing the change to flipped learning

- Teachers need to be flexible and to adapt their approaches on an ongoing basis in response to reflections on how flipped learning is working, as well as feedback from student progress and attainment data. Teachers will need to plan for how they will capitalise on additional lesson time gained through students coming more prepared. In other cases, they may need to allow time at the beginning of lessons to recap and reinforce home learning or to introduce new content where homework has not been consistently completed or understood.
- Flipped learning should be considered as one approach amongst the wide repertoire of teaching methods that can be used to suit the context and specific content of lessons. Feedback from teachers and students suggests that in some schools it will not be used for every homework exercise as it may not always be best suited to topics and the workload for students could be too high.

PART 1

Introduction

This small-scale qualitative study set out to explore how flipped learning can be delivered in mathematics. It also aimed to provide illustrative examples of the benefits and challenges of different approaches to flipped learning.

1.1 Flipped learning

Flipped learning involves the use of digital technology, such as video, to provide direct instruction on new concepts outside of the classroom. Students come to lessons already having a preliminary understanding of the topic, freeing up class time for the teacher to focus on other beneficial learning activities[1,2].

Although the term is in regular use amongst educators, flipped learning is used to describe a wide variety of different practices. There is variation in the resources used ranging from media such as enhanced textbooks, to students recording their own instructional videos[3,4]. Flipped learning most often refers to the use of video resources for instruction although, in some cases, these resources can be a blend of video, text and interactive exercises to demonstrate concepts or assess knowledge and understanding.

Often, but not always, 'flipping' the classroom refers to changing the location of the delivery of content, or the direct instruction phase of a teaching and learning cycle[5]. Traditionally, homework is used for practise and consolidation after lessons, but the flipped learning approach uses time at home for the delivery of new content before a lesson. The lesson time spent with an expert teacher is then used wholly for coaching, addressing misconceptions, and deepening understanding, rather than a portion of it being given over to all of the students receiving the same content.

Flipped learning can be used within almost any curriculum subject area. It is often used for the teaching of mathematics due to the abundance of resources for this subject and, to some extent, due to this subject being amenable to video instruction, online testing and modular chunking of curricula.

Originating from work by Eric Mazur on 'peer instruction', flipped learning has been popularised at school level by Salman Khan of the Khan Academy. Such approaches have been explored and developed by others ranging from commercial resource providers to individual teachers recording their own videos[6].

There is a growing body of evidence exploring the use of flipped learning, particularly in the US and Canada. Several small-scale studies have identified benefits associated with the approach in terms of maximising class time and teacher one-to-one support, supporting student-centred learning, personalisation of learning and increased pupil motivation[7,8]. However, medium-term research into the use of Khan Academy in the US has suggested that this resource for flipped learning is most often used as a textbook replacement in class rather than changing the location of instruction, or explicitly freeing class time for active learning[9]. There are also studies which have identified a range of challenges associated with the approach, chiefly access to computers, identifying or creating instructional materials and student engagement[10].

We explored the effects of asking teachers to 'flip' their classroom using resources to deliver direct instruction as homework before a lesson, and devoting lesson time to active learning activities based on pupils' resulting prior knowledge of the topic.

We used a specific definition of flipped learning to describe the activity we explored:

> *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. The activities undertaken in the classroom should, where available, be informed by online data (such as that collected through practice questions) which will show teachers what their students are doing and the pace they are moving at.*

1.2 The Khan Academy

As part of our study, teachers were asked to use Khan Academy (**www.khanacademy.org**) mathematics resources in their delivery of flipped learning. Relevant resources were mapped to the curricula for Key Stage 3 in England and Secondary 1-3 in Scotland to support teachers in identifying appropriate resources for their class in terms of level and content.

Khan Academy was founded in 2006 and it is one of the world's most popular education websites. It describes its mission as providing 'a free world-class education for anyone, everywhere'.

From its original roots in video instruction, Khan Academy has expanded its resources to provide a range of problems and exercises for students to complete to practise and develop their learning of concepts. These exercises are delivered using an 'adaptive' approach, which responds to students' performance and alters the questions delivered based on their previous answers. The system also records and tracks students' activities and performance to provide information for teachers on what they are doing and how well they are progressing.

The Khan Academy website offers some powerful reporting functions of benefit to teachers which allow them to:

- Explore gaps in students' understanding of key concepts: this affords the possibility of creating a baseline from which one can measure future improvement.

- Identify students who are struggling with a specific topic or concept: this can help teachers to select which approach might work best with different students. This could be peer tutoring with a proficient student or a one-to-one session or small group work with students who are struggling.
- Diagnose learning challenges: teachers are provided with data on how students have used the Khan resources. They will know, for example, whether or not a student has viewed the video and how many problems they have attempted. This information can help teachers to pinpoint conceptual misunderstandings and behavioural or confidence issues.

1.3 Aims of the study

The study set out to explore what effect a flipped learning approach has on teaching and learning in secondary and middle school mathematics.

The key research questions for the study were:

- Is there a difference in the activities taking place in a flipped classroom compared to a sample of mathematics lessons where the content is being delivered in a more traditional way?
- Are the activities which are seen in the flipped classroom likely to lead to improved attainment or deeper understanding than those seen in the traditional classroom?
- Do students and teachers report improved engagement or understanding when using the flipped classroom model?
- Do different groups of students (e.g. the more and less able) benefit differently from this form of learning?
- Does flipped learning lead to a greater degree of personalised learning for students and, if so, how is this achieved?

As the study used a small-scale case-study design, its purpose was not to provide comprehensive evidence of the benefits of the flipped learning approach. It was designed to provide illustrative examples of the benefits and challenges of different approaches to flipped learning, and to explore UK teachers' views on the suitability of the Khan Academy mathematics resources in supporting these approaches.

1.4 Methodology

The study took place in the academic year 2014-15 in three secondary schools and one middle school in England, and five high schools in Scotland. A mathematics teacher in each school selected a Key Stage 3/Secondary 1-3 class (students aged 11 to 14 years) to use the prescribed approach with a topic of work lasting around half a school term (4-6 weeks). A class in the same age group, but taught by a different teacher who was not using a flipped learning approach, was also selected for comparison. Where possible, both classes were selected to be of similar ability.

The **resources** initially used were those provided by Khan Academy. Preliminary discussions with teachers who had used these resources suggested a potential barrier to success was the time needed to link them to the curricula in schools. Therefore, documents were created which mapped the available videos and interactive exercises to the English and Scottish curricula for the target age group. This work was carried out by experienced mathematics teachers.

A guide to implementing the flipped learning approach was created and circulated to teachers. This covered the aims of the research, the approach we asked them to take to teaching and learning, and practical considerations such as how to generate user accounts for their class. It also set out a model process for implementing flipped learning emphasising an approach where new learning took place in students' homework time.

Before the implementation began, all students and teachers were asked to complete online surveys on their baseline attitudes towards mathematics and experiences of mathematics lessons. These surveys were repeated once the pilot had finished. Unfortunately, completion rates for the end-point surveys were very low due to the pilot finishing at the end of a school term and little usable data was generated. Case-study schools were sent individualised feedback reports on their students' responses to survey questions.

Teachers implemented the approach according to their professional judgement and context but were strongly encouraged to 'flip' their teaching towards delivery of new content as homework, and to make use of the analytics and reporting functions of the Khan Academy resources.

In the final week of using the flipped learning approach, each school was visited by a researcher from Nesta or NFER. With both the intervention and comparison class in each school, teacher interviews were conducted and small focus groups were facilitated with students. Interviews and focus groups were structured around a common set of questions relating to the research aims, with follow-up questions also included to explore responses in more detail. Interviews and focus group discussions were recorded to ensure detailed and accurate accounts. Permission for recording was sought from all participants, and the anonymous nature of their contributions explained. Care has been taken to anonymise all personal details and information that could identify particular teachers, classes or schools in this report.

Lesson observations were also undertaken with both the flipped learning and comparison class in each school, and teachers were invited to provide feedback on how typical the lessons observed had been and how they compared to normal lessons. A standard lesson observation schedule was used to note the structure of the lesson, teacher and student participation and activities taking place.

The following Table 1 provides details on the characteristics of the nine case-study schools. We aimed to involve schools with different levels of attainment and socio-economic contexts.

Table 1. Case-study school characteristics

Case study number	Country	School type	Age range	Number on roll	Percentage of pupils with a special needs statement or on School Action Plus	Percentage of pupils eligible for free school meals[11]	Percentage 5+ A*-C GCSEs (inc. English and maths) (2014)/ Percentage of S4 Roll achieving 5+ awards at SCQF Level (2012/13)
1	Scotland	Secondary, state-funded	12-18	960	Not known	4%	42%
2	Scotland	Secondary, state-funded	12-18	570	Not known	14%	42%
3	Scotland	Secondary, state-funded	12-18	320	Not known	6%	48%
4	Scotland	Secondary, state-funded	12-18	990	Not known	11%	66%
5	Scotland	Secondary, state-funded	12-18	880	Not known	12%	59%
6	England	Academy converter	9-13	550	6%	12%	n/a
7	England	Academy converter	11-18	1300	1%	1%	99%
8	England	Community School	11-16	1010	8%	33%	37%
9	England	Academy converter	11-18	1400	11%	21%	59%

N.B. Data is rounded.

1.5 Analysis and reporting

Initial notes from the interviews, focus groups and lesson observations were expanded after the visits using recordings, and verbatim quotes were added. Researchers then analysed and wrote up each case study using an analysis framework which was structured around common themes and questions. A qualitative data analysis tool, MAXQDA, was used to collate and organise the responses into segments on each theme, in preparation for more detailed thematic analysis. The collated data was then synthesised by researchers to identify common themes of impact, challenges and factors influencing the success of flipped learning.

In addition to this research report, a practically focused guide to implementing some of the approaches to flipped learning documented in the study has been produced. The guide is designed to provide more practical advice to teachers wishing to implement a flipped learning approach in their schools based on the findings of our research. By contrast, this report is intended to provide analysis and insight into the successes and challenges of the approach and impacts on teaching and learning, through research undertaken in case-study schools.

PART 2

Schools' implementation of flipped learning

This section draws on interviews with teachers and lesson observations. It describes how the pilot schools implemented flipped learning, the differences noted between flipped learning and more traditional teaching approaches, and the digital resources that teachers used for flipped learning.

2.1 How pilot schools implemented flipped learning

During the pilot, most of the schools implemented flipped learning as was envisaged, with the direct instruction part of learning being 'flipped' to take place outside of the timetabled school day. For homework, students watched online instructional videos and presentations and did exercises introducing them to a new topic in preparation for class time.

At the beginning of flipped learning lessons, teachers usually provided a brief introduction and used questioning to gauge students' levels of understanding from watching online videos to inform the activities of the lesson. In one case, the teacher displayed the analytic data produced from students' participation with Khan Academy exercises to show each student's understanding and performance. Then, teachers encouraged students who understood the topic to support their peers and some teachers paired students to support this process. In some cases, a

substantial number of students had not engaged with the videos for homework (due to issues of student engagement with homework or technical barriers), or had watched the videos but not fully understood them. In these cases, the teacher replayed videos in class or spent time reiterating the content and clarifying understandings and correcting misconceptions.

Flipped learning class time tended to be used mainly for offline learning, such as working through activities in a textbook. Students in flipped learning classes worked relatively independently through set activities focusing on applying skills and procedures. Students were often encouraged to discuss their work with peers next to them and in small groups. The teachers also led whole-class discussion, often as a plenary activity.

Flipped learning teachers described how they were able to spend more time than in a traditional class circulating around students as they worked through activities, providing coaching support for individuals and small groups who were struggling. This was interspersed with bringing the class together as a whole group to tutor them through specific concepts and topics that were proving challenging for students.

Two case-study schools implemented a slightly different approach to flipped learning due to issues faced relating to student engagement with homework and home computer access. These and other barriers to flipped learning are discussed in section 4.2. To counter these issues, schools used online instructional videos and exercises as part of class time activities to introduce concepts and topics and to support consolidation of learning through practising and applying skills.

One school used Khan Academy mathematics videos and exercises in lessons as one of six 'workstations' in a carousel of activities. Students logged into their Khan Academy account on individual iPads and then worked at their own pace through activities on the particular topic set. Students were then encouraged to continue working through activities for homework to extend and consolidate their learning.

Another school adapted the concept of flipped learning by delivering one out of a total of four weekly mathematics lessons in the computer suite where students used Khan Academy mathematics resources. The lesson was essentially run as a managed homework session supervised by a non-specialist teacher. In the session, students sat at individual work stations and progressed through Khan Academy materials set by the teacher to introduce them to a new topic. The non-specialist teacher encouraged students to help each other if they were having difficulties. Students were also encouraged to engage with the Khan Academy materials as part of homework. With poor internet access at home due to the rural setting and an existing homework policy of two hours' homework per night, the teacher was reluctant to place an additional burden on the students by making this a formal requirement. Subsequent lessons, taught by the specialist mathematics teacher, continued the topic using offline resources, and built upon students' learning from using Khan Academy resources.

Two vignettes illustrating how pilot schools taught mathematics using flipped learning are provided below.

VIGNETTE A: FLIPPED LEARNING USING KHAN ACADEMY MATERIALS AND ANALYTICS DATA FOR MONITORING PROGRESS

The flipped learning pilot was carried out with a Secondary 3 class (aged 13-14 years) of high ability students. The class was introduced to a topic on graphical functions using Khan Academy videos and exercises during homework time. Class lessons then began with the teacher displaying the results of the analytics from the homework exercise on the board. As students entered the lessons they could see how well they and their peers had done. The use of the Khan Academy analytics data allowed the students to compare their performance with peers and for the teacher to monitor participation and understanding and diagnose the need for further support. The teacher's introduction to the lesson was brief and quickly

progressed to setting students a problem-solving activity based on the topic. The students worked independently through the activity and those who were struggling were encouraged to consult with their peers who had performed well in the related exercises, based on the displayed analytics of student performance. The class was later brought together as a group to go through the exercise; the teacher inviting different approaches to solving it and offering praise for different methods. For the remainder of the lesson, students worked independently through textbook questions, interacting with each other to seek or offer help. The teacher spent extended time with individuals and pairs who were struggling and, at one point, brought the whole class together to complete a worked example encouraging student contributions. The teacher reported that the lesson was more student-centred than the usual, more traditional, teaching approach. The teacher plans to continue using a flipped learning approach to complement more traditional methods and to teach particular mathematics topics, and will encourage other members of their department to do so. The teacher also intends to continue to use Khan Academy materials and analytics data for diagnostic purposes.

VIGNETTE B: FLIPPED LEARNING USING 'HEGARTY MATHS' AND PEER-TO-PEER LEARNING IN CLASS

The flipped learning pilot was carried out with a Year 9 class (aged 13-14 years) of middle ability students. Initially, the teacher began the flipped learning pilot using the Khan Academy resources but found the site hard to navigate and was concerned that the explanation of concepts offered in the videos would not be accessible for her students and could lead to misunderstanding. Instead, the teacher used 'Hegarty Maths' resources, which they found more closely aligned with their own teaching style and way of explaining concepts. During a topic on ratios, students were set homework to watch videos in preparation for lessons. Some students did not complete the homework and needed support from the teacher and from other students in class to catch-up on the information they had missed. However, the majority of students came into the classroom and *'hit the ground running'* because they had watched the videos and were able to progress through the lesson plan of worksheets more quickly. The flipped learning teacher managed the different levels of understanding by asking students who had watched the videos and understood the content to support those who had not seen them or were struggling with concepts. The teacher found this worked well as the students could hear different explanations and enjoyed working in groups and explaining concepts to each other, which deepened their understanding. The teacher felt that the flipped learning approach helped to develop independent study skills where students engaged with the preliminary homework. Additionally, students completing the homework worked at a faster pace in lessons and made more progress. The teacher planned to continue to use flipped learning as part of a blended approach of offline and online learning, as well as greater use of peer-to-peer learning through developing student 'experts'.

2.2 How flipped learning differs from more traditional teaching approaches

There are a number of features which distinguish a flipped learning approach from traditional teaching approaches and which were evident in case-study schools' piloting of different approaches to implementing flipped learning.

Homework

In the flipped learning approach, **homework time is typically used to prepare for lessons** through students watching online instructional videos and presentations on a particular topic prior to lessons. Traditional teaching approaches tend to use homework time for consolidation, extension and revision as a follow-up to lessons. However, some schools in the pilot also used online resources as a way of consolidating learning. For instance, students could continue working through set Khan Academy videos and exercises in their own time.

Online and offline learning

In the flipped learning approach, teachers made **greater use of online learning,** using online videos, presentations and exercises. According to teachers, traditional approaches to teaching mathematics tend to involve predominantly offline learning, such as students working through textbooks and worksheets. Hence, flipped learning provides opportunities for more varied modes of learning.

Teacher as facilitator or coach

In the flipped learning approach, **teachers spent more time coaching students and facilitating learning** and less time on initial instruction and demonstration, which had been provided via instructional video content set for homework. Teachers using the traditional teaching approach usually started the lesson by providing an introduction to a topic, going through examples with the whole class and with students making notes on the procedure. By contrast, in flipped learning lessons, teachers spent less time on this initial part of the lesson and moved quickly onto setting the class activities to apply the learning, following brief whole-class question and answer sessions to assess students' understanding. The time saved in lessons on providing the initial instruction and demonstration was used for a range of active teaching and learning practices, which are discussed further in section 3.

2.3 Online resources used for flipped learning

As reported earlier, teachers were asked to use Khan Academy (www.khanacademy.org) mathematics resources in their delivery of flipped learning. Teachers who used the Khan Academy resource valued: the range of topics covered; the reporting functions to enable the teacher to gauge students' participation and understanding; and the immediate feedback to students on their performance in the exercises. However, in several cases, schools used other resources in addition to Khan Academy, or as an alternative to them (discussed in section 4.2). These other resources included:

- Hegarty Maths (**www.hegartymaths.com**) – set up in 2011, and inspired by Khan Academy, Hegarty Maths provides videos and resources for all aspects of the mathematics curriculum that enable students to improve their mathematical skills in and outside of the classroom. There is a free and a paid for version.
- MathsWatch (**www.mathswatch.co.uk**) - MathsWatch is a set of mathematics resources (videos and worksheets) available to schools/colleges via an online subscription service or via the purchase of individual discs.
- MyMaths (**www.mymaths.co.uk**) - MyMaths is an online learning platform for schools. Although based in the UK, MyMaths is used in over 70 countries and by over four million students a year. MyMaths provides access to a range of ready-made lessons and online homework tasks.
- YouTube (**www.youtube.com**) - launched in May 2005, YouTube allows people to discover, watch and share originally-created videos, including a range of educational resources.
- BBC Bitesize (**www.bbc.co.uk/education**) – launched in 1998, this is a free online study support resource for primary and secondary students across the UK. Bitesize is available on a variety of platforms, including web and mobile phones, and provides a range of classroom resources, such as video clips, activities and tests.
- NCETM (National Centre for Excellence in the Teaching of Mathematics) (**www.ncetm.org.uk**) provides mathematics teaching resources, including schemes of work, lesson plans and links to other online resources.
- Mathsrevision.com (**www.mathsrevision.com**) – this is a set of mathematics resources (presentations, lessons and exercises) available online which were created by a teacher and are linked to the Scottish mathematics curriculum.

These resources have been listed to give a flavour of the range of resources available to support a flipped learning approach, and the list is by no means exhaustive.

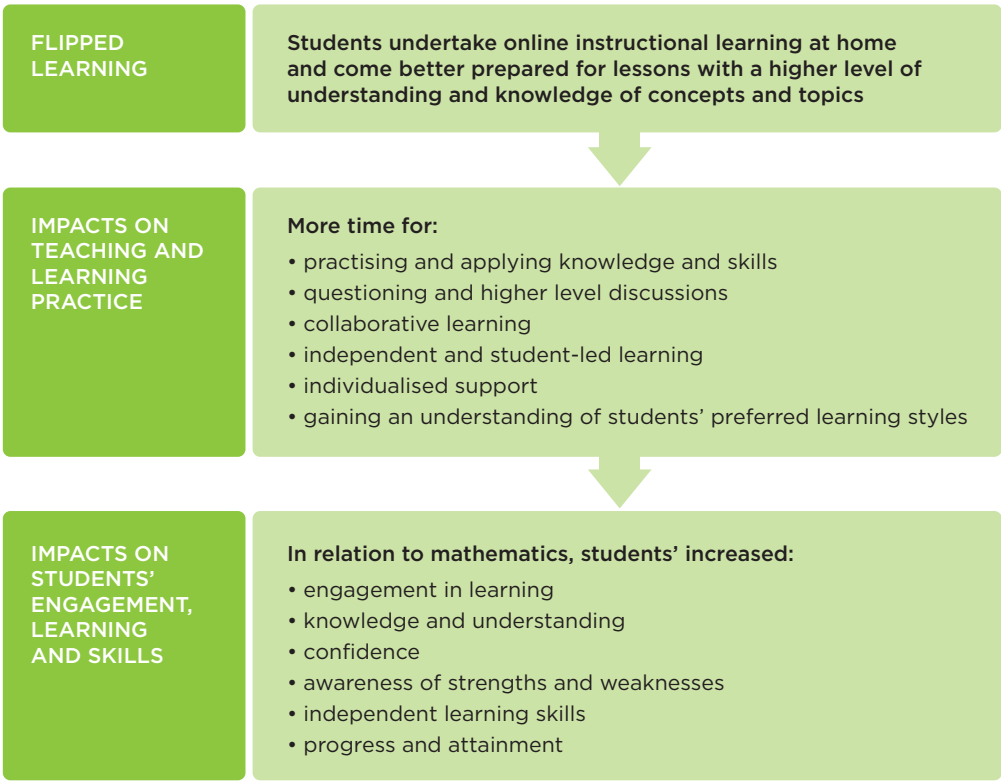
PART 3

The impacts of flipped learning

This section explores the impacts of flipped learning on teaching and learning practice and on students' engagement, learning and skills in mathematics. It also includes views of teachers regarding the types of students who appear to benefit the most or the least from the approach. The impacts described here relate specifically to mathematics teaching and learning but they are likely to apply to other curriculum subjects.

Teachers had mixed opinions in terms of how and the extent to which they would use flipped learning. While all teachers identified benefits of flipped learning, and most were keen to continue using it, some also reported challenges in using it (see section 4.2). This section reports the benefits of using flipped learning where it has been effectively implemented and students have actively engaged with the approach. Figure 1 below provides an overview of the impacts of flipped learning reported by case-study teachers during interviews[12]. Each impact is then discussed in more detail in the following sections.

Figure 1. Overview of the impacts of flipped learning



3.1 Impacts on teaching and learning practice

Teachers reported a range of improvements in the quality of teaching and learning in their classroom where their students engaged fully with the flipped learning homework. These improvements were achieved by students coming to lessons much better prepared as result of covering key content for homework and, in some cases, making notes whilst watching the videos:

> *"I think flipped learning is brilliant. I think it is fantastic that they (students) come in at a better starting point."*
>
> **(Teacher, case study 10).**

In undertaking their homework, students could spend as long as they needed watching instructional videos and could listen to the explanations several times to grasp new concepts. As a result, students were reported to be coming to lessons with a similar level of understanding which made it easier for teachers to plan and manage the lesson.

> *"They've got the chance to spend as long as they like on it whereas, in class, they don't really get that chance because someone will get it in two minutes but they maybe need 15, it can really set them back. Whereas if they all get chance to do it at home, one person took two minutes, one took 15, it doesn't matter because they've all come to class and they are ready to move on from that point together..."*
>
> **(Teacher, case study 1).**

Teachers reported that, as a result of students learning and grasping new content at home, they did not need to spend as much time on explanations at the start of lessons. This meant that more could be covered in class time which progressed at a faster pace.

> *"More progress, working at a faster pace you also get more work done."*
>
> **(Teacher case study 4).**

The time that was saved was used by teachers in a range of beneficial ways as detailed below.

3.1.1 Practising and applying knowledge and skills

With students coming into lessons with an existing level of knowledge and understanding of the topic, they were able to spend more time practising and applying knowledge and skills, such as working through exercises and problems and undertaking extension activities:

> *"...it gave us a chance to go straight into practise..."*
>
> **(Teacher, case study 1).**

3.1.2 Questioning and higher level discussions

Teachers reported that they were able to give more time to student questioning and to extended, higher level discussions of the topic:

> *"It made better use of me, rather than sitting here while they copied stuff down off the board, they could ask questions about things when they were struggling...there was more discussion as a result of doing the flipped learning..."*
>
> **(Teacher, case study 1).**

3.1.3 Collaborative learning

Teachers described how flipped learning had facilitated more opportunities in class for peer-to-peer and collaborative student learning. Teachers piloting flipped learning often asked those students who had completed and understood the homework to work in pairs or small groups to explain concepts and topics to other students who were struggling. Some teachers also commented that students were taking the initiative to share their learning and knowledge and to support each other without being prompted and were keen to demonstrate what they had learnt:

> *"... without saying anything the class was already helping each other out, teaching each other... because it's expected of them to know it, they've got the opportunity to take responsibility for it."*
>
> **(Teacher, case study 1).**

> *"It's encouraged huge collaboration between pupils..."*
>
> **(Teacher, case study 6).**

3.1.4 Independent and student-led learning

Some teachers reported that the flipped learning approach enabled them to facilitate more opportunities for independent and student-led learning. Teachers described how their students were working more independently as they had to take responsibility for watching the instructional videos at home and could work independently through set videos and exercises at their own pace. The flipped learning approach put a greater onus on students to take responsibility for their learning, rather than relying on the teacher to impart all of the information. One teacher had given students the challenge of leading the lesson after they had learnt about the topic for homework:

> *"Flipped learning provided an easier opportunity at the start of the lesson for pupils to become more actively involved in the delivery of the lesson."*
>
> **(Teacher, case study 1).**

> *"They were able to just go off and do it. All I was dealing with were minor misconceptions."*
>
> **(Teacher, case study 8).**

3.1.5 Individualised support

Most teachers reported that the flipped learning approach allowed them to take on a more coaching role and spend more time supporting individual students and small groups in class. Teachers in flipped learning classes spent more time with students who were struggling with a topic or concept, clarifying understandings and tackling misconceptions, discussing different approaches to problem solving, responding to students' questions, and helping more able students work through extension exercises. Flipped learning enabled more personalised forms of learning; students could learn independently and at their own pace and teachers could have individual discussions with pupils to check on progress and deepen understanding:

> *"In terms of individual contact with pupils, that's increased a lot."*
>
> **(Teacher, case study 4).**

> *"Undoubtedly, those that had learned* [and accessed the video instruction at home] *we could push on and give them extension activities and could have individual-based discussion with them about what they'd done and deepen their understanding…"*
>
> **(Teacher, case study 1).**

The scope for more personalised learning through the use of online resources which provide individualised feedback and targeting of activities was perhaps not exploited to its full potential during the pilot. Personalised learning and differentiation in lessons tended to occur as it might in a more traditional model, with students working through progressively challenging activities at their own pace.

3.1.6 Gaining an understanding of students' preferences

Most teachers reported that flipped learning had enabled them to gain a better understanding of students' preferences for different approaches to learning. In particular, they had a better understanding of students who were able to take more control of their own learning and who responded well to independent tasks:

> *"It helped us to identify those pupils that are responsible and independent in their learning and are most determined to succeed. When you take away the person at the front and say 'It's over to you', some pupils at that age can respond to that... It's given me a really good insight into who's doing the work and who's really keen."*
>
> **(Teacher, case study 1).**

3.2 Impacts on students' engagement, learning and skills

Teachers reported a range of impacts that had been realised for students as a result of introducing flipped learning, most of which were reflected by students in their own reports.

3.2.1 Engagement in mathematics learning

Teachers and students both reported that, as result of using online resources, students found lessons and homework more engaging and 'fun'. To some extent, this was related to the approach being new and fresh and a change from traditional teaching approaches that used technology less frequently. However, it was also related to other changes teachers had made to lessons, such as asking students to deliver the first part of the lesson themselves. In some cases, students' increased enjoyment of lessons and homework was changing their attitudes towards mathematics as a subject. Some students who previously said that they 'hated' mathematics were now reporting that they liked it:

> *"Khan Academy makes maths lessons a lot easier and a lot more fun. Before they weren't always fun, but now they all are."*
>
> **(Student, case study 8).**

> *"It can make maths more engaging and you are more motivated to do it because it is not text book."*
>
> **(Student, case study 2).**

> *"One student who isn't particularly keen on maths told me that she just loved it because she's got a better starting point (her words) when she comes to the lesson and others jumped on board and said, 'so do I'."*
>
> **(Teacher, case study 8).**

3.2.2 Mathematics knowledge and understanding

Teachers and students also both reported that flipped learning had helped some students to develop a deeper knowledge and understanding of mathematics topics. This was a result of having more time to absorb the information at their own pace out of lessons and then having more time in lessons to: practise and apply skills; participate in discussion and peer-to-peer learning; and receive individualised support from the teacher to further extend and consolidate their knowledge.

For instance, students reported that, if their friends had not watched the video, they were explaining it to them which had an added benefit of helping them to gain a deeper understanding:

> *"If one of our friends didn't watch it we will explain it... we all kind of work together... I think it's good because it makes you understand better if you explain it to someone else."*
>
> **(Student, case study 5).**

However, as discussed in 4.2, some students did not always understand the content if it was not effectively explained and scaffolded in the videos.

3.2.3 Confidence in mathematics

Another important impact was students' increased confidence in mathematics. This was related to their increased knowledge and understanding gained through regular homework and independent learning which had resulted in a realisation that they could be successful in mathematics. Teachers also reported that, where students were asked to look at the resources for homework, they came to lessons feeling more confident that they would understand the lesson and be able to engage with it:

> *"Having come in at a better starting point the class had increased confidence, rather than facing the uphill they have when you don't use flip."*
>
> **(Teacher, case study 8).**

3.2.4 Awareness of strengths and weaknesses

Teachers and students also noted an impact on students' understanding of their strengths and areas for development, as well as their increased independence as a learner. Flipped learning had enabled students to gain a better understanding of what they did and did not know or understand and the opportunity to work on areas they struggled with. In addition, through the process, students had become much more accurate and detailed in assessing their learning and explaining what they needed to work on. To some extent, students' greater and more accurate awareness of their strengths and weaknesses went hand-in-hand with their increased independence when they spent time at home working on concepts and topics that they found more difficult. Feedback on their performance on online exercises also helped students to understand how well they were doing:

> *"The approach is making students more aware of what they do and don't know, and enabling them, in some cases, to remedy areas they need to do more work on by independently working through particular activities."*
>
> **(Teacher, case study 6).**

3.2.5 Independent learning skills

Teachers felt that a flipped learning approach helped some students to develop independent learning skills. For instance, providing learning resources for students to access in their own time enabled them to understand they could learn for themselves and did not need to be reliant on their teacher for obtaining information and knowledge. The flipped learning pilot encouraged some students to research and use additional sources of information and activities to help them understand particular topics and make progress. One teacher mentioned that getting students into a habit of taking responsibility for learning by doing small amounts of regular homework helped them to develop a positive work ethic which would be valuable in their future schooling and careers:

> *"Flipped learning is a really good way of getting students to be more independent. It encouraged a culture of independence as the other students see those who get it doing well and getting ahead and they want to do the same."*
>
> **(Teacher, case study 9).**

> *"I like independent learning because you are thinking by yourself and you can work at your own speed."*
>
> **(Student, case study 9).**

> *"Some students have spent time at home working on maths beyond the expected homework, with some independently accessing information and bringing new facts and ideas to their subsequent lessons."*
>
> **(Teacher, case study 6).**

3.2.6 Progress and attainment

An important impact of flipped learning for some students appeared to be faster progress and improved attainment. In some cases, quicker progress was related to students spending more time on their homework and going beyond what had been set, as mentioned above. This related to their enjoyment of the method and increased engagement with their own learning. Both teachers and students reported moving at a faster pace within lessons and moving on to more advanced work. This was corroborated in lesson observations in which researchers observed students in flipped learning classes moving more quickly onto task than students in the comparison group. A number of teachers and students went as far as to say that students' attainment had improved during the pilot, or that flipped learning had the potential to improve attainment in the longer term:

> *"The flipped learning approach means that you get more out of the lesson because you already have a bit of knowledge before you go in. The teacher would usually have to explain for most of the lesson if she's starting a new topic, so she doesn't have to do that as much, so we get more done and get onto harder questions."*
>
> **(Student, case study 1).**

> *"I have found that I am able to move at a much faster pace than I was before. I was finding that I couldn't cover everything I wanted in lesson but I am definitely getting more out of them now. They are definitely making more progress as a result of flipped learning."*
>
> **(Teacher, case study 9).**

3.3 Impacts for different students

Some teachers qualified their reports of student impacts by explaining that some groups of students had benefitted more from the flipped learning approach than others. This included highly engaged students, higher achievers and, in some cases, girls.

Teachers reported that highly engaged students did their homework as instructed and, as a result, were able to take a full part in the lesson the next day. Some more able students benefited from the approach because they could more easily work independently and at their own speed and were not held back by others who had a less advanced understanding of the concept or topic. As this teacher explained:

> *"There are some students* [the more able] *who get really frustrated when other children mess about and disrupt their learning, or break up the flow of the lesson. For them, the flipped learning approach of using instructional videos is really good because they can work independently and at their own speed."*
>
> **(Teacher, case study 9).**

Teachers reported that students who struggled with mathematics had not benefited as much from flipped learning. Some of these students had poor organisation skills and would not look at the videos for homework, whilst others who did would get frustrated when they could not understand something and were unable to ask a teacher.

One teacher reported that girls in the class had particularly engaged with, and benefitted from, flipped learning. This was described as being because they tended to be better organised and methodical and could see the merits of the approach. Boys were more likely to see the video at the last minute as a group. However, boys responded well when they were asked to feed back what they had learnt to the class:

> *"I think girls were the easiest to get on board. They are more organised, methodical and see the benefits of things. Girls like to go away, they do it on their own. They don't need me. Boys like to come and watch the videos as a group in the classroom at break. Boys do it when they get to the point where they realise they can't get away with not doing it. I think the boys respond better to feeding back on what they have learnt in class.*
>
> **(Teacher, case study 8).**

However, some teachers acknowledged that, for the majority of students, attitudes had changed and become more positive over the course of the pilot. They reported that they expected student impacts to increase over time as they and their students became more used to the new approach:

> *"For the majority, it has made a difference, the more we run it the more of a difference it would make..."*
>
> **(Teacher, case study 6).**

PART 4

Factors influencing the effectiveness of flipped learning

The range of impacts realised through the implementation of flipped learning in pilot schools, described in Chapter 3, resulted from various factors. Some of these factors were context-specific whilst others were more general. Our analysis revealed a number of themes relating to the enablers and barriers to success of the approach. In some cases, these enablers were capitalised on, and/or the barriers overcome, resulting in the success of the approach. In others, particular barriers limited the impact achieved. Further details are provided below.

Figure 2. Overview of enablers of success and barriers to success

ENABLERS OF SUCCESS		BARRIERS TO SUCCESS
• Access to wifi and PCs/laptops/ smart phones at home and school	**Access to technology**	• Insufficient/inadequate technology provision and speed of connection at school and home
• Relevant to curriculum • Appropriate to students' level and capabilities	**Identifying appropriate video/digital resources**	• Content and explanations not consistent with teacher's • Resources do not scaffold learning sufficiently
• High ability/highly engaged students • Students with independent learning skills	**Attitudes and capabilities of students**	• Students not comfortable learning independently • Students become disengaged when they do not understand topics/ concepts for homework
• High expectations for homework embedded in school culture	**Homework culture**	• Homework not consistently completed and/or not mandatory • Homework non-completion requires teacher to undertake instruction at the beginning of lessons and time is not saved
• Fits with teacher's identity and perception of teaching role as facilitator of learning e.g. through questioning and coaching/mentoring • Teacher capacity and willingness to manage change and take an iterative approach	**Teacher identity, role and capacity to manage change**	• Teachers not comfortable delegating responsibility for initial instruction and see instruction as part of their identity as a teacher • Lack of capacity/capability to pilot new ways of working and make adaptations as needed

4.1 Enablers of success

4.1.1 Access to technology

In the schools that successfully implemented flipped learning, access to technology was clearly a key factor. Although access to technology is essential for flipped learning, there were a range of approaches taken to this depending on the availability of PCs and laptops.

Mathematics classrooms in pilot schools were not equipped with access to enough computers for all students to have one-to-one access, although many had projectors that were used to watch videos as a whole class. However, where access to technology was an enabler of success, this was achieved in different ways.

In one school, tablet computers were provided to all students during the pilot which they were able to use both at home and in school. The student focus group reported how this made it easy for them to access the resources required, enabling them to engage with the work they were set rather than being distracted by not having the necessary access to technology.

In a minority of cases, technology access in students' homes was limited. To overcome this challenge, one school encouraged students to use their smart phones to access videos, providing students with direct links to access the videos on YouTube. However, the teacher in this school noted the importance of making students aware of data usage and making sure this would not incur personal financial costs:

> *"I was quite surprised by how many students were able to use their phones and had cheap or free data on their phones, quite a lot of them did it that way."*
>
> **(Teacher, case study 5).**

Several schools provided their students with access to IT equipment outside of lesson time in lunch breaks and after school, either as part of existing provision or as a new initiative.

In one school, timetabling had allowed one mathematics lesson a week to take place in an IT suite with computers for all students. This lesson was supervised by a non-specialist teacher, due to staff capacity, and was managed like a supervised homework club.

4.1.2 Identifying appropriate video/digital resources

The documents provided by the pilot evaluators, which mapped the Khan Academy resources to the curricula, were identified by several schools as one of the factors enabling success. As one teacher stated: 'It would be impossible to do this without that [the mapping resource]'. With teachers needing to structure the progress of their lessons around a curriculum, the mapping was seen to be an important reference tool for schools that successfully implemented a flipped learning approach. As one teacher reported:

> *"The large spreadsheets you have created linking the curriculum with what's going on in the Khan Academy is a really useful tool for that, and I think that's something that, if you were to develop it, would be a really useful thing ."*
>
> **(Teacher, case study 5).**

One teacher decided to source mathematics videos from an alternative site because it was already structured to align with the curriculum areas, negating the need for a separate mapping resource. Again, ease of access to resources that were appropriate and relevant to the curriculum was crucial in supporting the implementation of a flipped learning approach in this school:

> *"Hegarty Maths is so well structured, it's quite easy to pull together lists of videos quickly."*
>
> **(Teacher, case study 9).**

Across the pilot schools, teachers used their national curricula as a key starting point for structuring their flipped learning lessons. Some students branched off into other areas of learning as an extension after completing prescribed work, but no schools suspended their usual curriculum for the pilot to use the structure of Khan Academy. Curriculum linking of resources was a key enabler for this teaching approach to take place.

4.1.3 Attitudes and capabilities of students

When selecting classes for the pilot, six out of nine case-study teachers chose groups classed as high ability in mathematics; two case-study schools piloted the approach with middle ability groups; and one with low ability students. In several cases, this decision was influenced by the perception that high ability students would have the independent learning skills needed to successfully learn new content at home, or that they would have a good enough understanding of basic concepts which could be successfully built on. In a school that was overall less successful in implementing flipped learning, the teacher noted that the higher ability students in the mixed class were progressing well using the approach.

It was reported by a teacher, and several groups of students, that the Khan Academy videos cover a large number of concepts in each video and often move quickly between them and through steps. Several teachers commented that this provided a level of challenge most appropriate to higher ability students:

> *"With the benefit of hindsight, it might be that this approach works best with more able students, or students that are more used to taking responsibility for their own learning."*
>
> **(Teacher, case study 2).**

> *"It's more a maturity thing … if you ran this with a higher class, I think they'd get a lot more out of it."*
>
> **(Teacher, case study 4).**

However, other video resources approach the content in different ways so, to some extent, the enabling factor is matching the group of students to the most appropriate resources rather than the level, ability and maturity of students.

4.1.4 Homework culture

With direct instruction of new content taking place as homework, reliable completion of this activity is key to the success of flipped learning. Some schools enabled completion of homework by providing time and access to technology outside of lessons but in school time, whilst others introduced clear expectations for completion of homework and sanctions for those not completing tasks. In some cases, it took time for the new approach to become embedded, as one teacher reported:

> *"It took quite a bit of time to get up and running … there were technical reasons, but I think perhaps more importantly there were learning reasons. The thought that if you don't watch this then you aren't going to be able to contribute to the lesson the next day…"*
>
> **(Teacher, case study 5).**

Some schools had an existing culture of high expectations for completion of homework and, in these cases, this was an enabling factor for successful implementation. As one teacher reported:

> *"Students expect to get, on average, three pieces of homework a day corresponding to an hour or an hour and a half of work. Generally, the students are very good at completing homework."*
>
> **(Teacher, case study 7).**

Where homework was not as strongly embedded in school culture (at least for the age group of the students participating in the pilot), several teachers placed ongoing emphasis on the importance of homework to their students and used sanctions to enforce this. It is strongly advised that teachers wishing to implement a flipped learning approach review the current culture of homework in their schools, and consider the steps they may need to take to ensure a high level of completion. This could be an introductory step before moving to a situation where homework completion becomes imperative to the success of lessons. Otherwise, schools could consider opening up access to IT suites during lunch-times or running sessions in the IT suite facilitated by a non-specialist teacher.

Student attitudes to the homework were mixed, depending on the amount of homework they were used to. Some groups reported an increased workload whereas, for others, the ability to move quickly through exercises as a result of the adaptive engine employed in Khan Academy led to a perceived reduction in work. As a student in this latter group commented:

> *"It takes less time than normal homework to do this."*
>
> **(Student, case study 1).**

4.1.5 Teacher identity, role and capacity to manage change

Key to the delivery of flipped learning is teachers delegating responsibility for initial instruction on concepts/topics to online and digital resources which students engage with outside of the normal lesson. Alongside this, teachers need to increase their role as facilitators of learning through, for example, questioning and coaching/mentoring individuals and groups of students. Some teachers saw these types of activity as a strong aspect of their identity as teachers. They identified with the Socratic model of a teacher as a mentor, questioning students to understand their misconceptions and guiding them to reconfigure their understanding.

In addition, as with any innovation in schools, the capacity and willingness of teachers to manage the changes required is crucial. While all teachers who attempted the flipped learning approach had elected to do so, some were able to manage change and meet challenges more comprehensively than others due to their workload, seniority within the school, or ability to take an iterative approach.

The capacity to evaluate and adapt the flipped learning approach towards flipped learning, making small changes until it fits the school context is important. However, teachers had different opportunities to approach the new initiative flexibly depending on, for example, the current attainment of the class, the pressures and constraints of examinations, and the school culture and expectations.

In some schools, teachers were able to give more time to the development of the approach before needing to see results. They reported that they had been able to take time for students to get used to the approach, and for them to hone it for their setting before they became overly concerned about the impact on learning.

Arguably, the most successful implementation of flipped learning in the pilot included the capacity for some flexibility and ongoing development, allowing the approach to be tried out and adapted to the context and students (e.g. replaying videos in class for students who had not completed the homework).

Two of the most successful pilots in terms of integrating a flipped learning approach into everyday teaching were run by heads of department, who clearly had more capacity for reflecting on the teaching approach they took and making adaptations in response to challenges presented by the transition.

4.2 Barriers to success

4.2.1 Access to technology

If there is not sufficient provision of technology for every student to regularly access the required online resources, flipped learning cannot be successfully implemented. As noted in the enablers of success, this does not always need to be a one computer per student environment. However, in a small number of cases where technology could not be managed in such a way that every student had access to the resources in between every lesson, the approach was not successful.

Students in one school spoke of having access to broadband and devices at home, but these were often being prioritised for older siblings' schoolwork or parents' work. In one school in Scotland, lack of consistent access to technology was the limiting factor that prevented a flipped learning approach from being adopted. It appeared that this was often due to the age and condition of available technology in homes, the speed of the internet connection and/or operating system and the technical skills of students as they talked of not being able to get the videos to play and not having flash software installed. As one teacher commented:

> *"It* [flipped learning] *falls down quickly when you've got disparity of provision, if you can't get all your pupils to access it or there's even small access issues, it can knock staff confidence in delivery, it has to be robust ."*
>
> **(Teacher, case study 1).**

Some more minor technical barriers were reported by students regarding the challenge of inputting certain types of answers into a computer based system:

> *"On the pi questions, there was no pi button on my computer ... I had to keep re- loading the page until there was a question that didn't have pi in it."*
>
> **(Student, case study 7).**

4.2.2 Identifying appropriate video/digital resources

In some schools, the content of the Khan Academy resources provided in the pilot were seen to be very different to the content covered in usual teaching, which meant that, as well as 'flipping' the location of the learning, the content of the learning was also significantly different.

Some teachers and students discussed the noticeable differences in how subjects were explained and, in some cases, noted differences in the mathematical terms used. Examples of such terms given were the full stop to signify multiplication or the use of US money such as a 'dime', the numerical value of which students were unfamiliar with. Teachers had varying attitudes towards these differences. Some noted them as a barrier to understanding whilst others thought it was beneficial for students to experience different explanations and to broaden their perspective on mathematics as a subject.

Where the Khan Academy resources were perceived to be a strong barrier to success, it was due to a perception that they were too complex, too challenging, or not structured as the teacher would normally plan a sequence of learning. As one teacher reported:

> *"I found it very time consuming because I had to go through everything I was going to show them to make sure it was reasonable because sometimes it would get to a point in the video and it would leap in difficulty."*
>
> **(Teacher, case study 3).**

A teacher in one school decided that the Khan Academy material was too challenging. Despite students conscientiously completing homework, enough were struggling with the content that the teacher decided to revert to the standard approach to teaching. This teacher noted that the teaching videos started with complex problems rather than building up slowly in complexity, and did not break down and scaffold the explanation of concepts in the way they would usually. This sentiment was echoed by other teachers and students in the study:

> *"It felt like for a lot of the videos he was jumping right in with quite a difficult question."*
>
> **(Teacher, case study 7).**

> *"At present, the sequencing of the content doesn't really support self-teaching."*
>
> **Teacher, case study 2).**

> *"Some of the videos, they don't help with the actual questions. .. there are lots of videos but I think what would be helpful is a video of the question, and then the actual question."*
>
> **(Student, case study 6).**

Interestingly, the teacher who discontinued flipped learning did not focus their critique on the general flipped learning approach and this teacher is, in fact, producing some of their own videos to attempt this approach again with content they feel is better matched to their students. Another school opted to use a flipped learning approach but replaced the Khan Academy resources with a set of video lessons produced by a UK teacher under the banner 'Hegarty Maths'. They explained that these videos were created to be linked to the curriculum, and also matched the approach they took to teaching themselves:

> *"I am very happy to have Mr Hegarty in my lessons! His lessons are very clear and complement my own."*
>
> **(Teacher, case study 9).**

Students noted some procedural and design limitations of the resources that they felt were a barrier to their learning compared to traditional methods. The Khan Academy exercises have a focus on mastery, with high expectations for correct answers before they allow students to move on. Students from several schools made similar comments on this point:

> *"The only thing that is slightly frustrating about it is where you have to get five* [correct answers] *in a row."*
>
> **(Student, case study 2).**

Students also reported the limitations of the Khan system in terms of revisiting their work to review problems, and to revise from examples and notes. For many students, moving through an online system was a very different experience to amassing notes, worked examples and practice questions in their books which they could then revisit. One student summed this up:

> *"In class, I quite like being able to go back though my book and go 'OK' got loads of those right, I need to go back and ask the teacher about those."*
>
> **(Student, case study 6).**

4.2.3 Attitudes and capabilities of students

In some cases, students' attitudes and capabilities were a barrier to the success of a flipped learning approach. Some students disliked the use of computers for their mathematics learning, saying they preferred pen and paper as it gave them a permanent record of their learning and they did not like looking at screens all the time. Other students reported that they preferred hearing explanations from a 'real person' who was physically present, allowing them to interact with their teacher at the point when they first met new concepts so that they could ask questions and check their understanding. Some students favoured this face-to-face and more guided approach and felt that learning new content independently of the teacher was more challenging and risked the development of misconceptions. Some students reported feeling disengaged and anxious when they did not understand the video content for homework and could not immediately clarify their understanding with a teacher.

4.2.4 Homework culture

For a flipped learning approach to be implemented effectively, students have to complete the homework. In some schools, this was a barrier to success because the students were not used to consistently completing homework. As one teacher commented:

> *"It was a mandatory requirement to do this to be able to participate in the class the next day, but because they saw, in the first instance, if there were only 7 or 8 pupils managing to complete it and then we paired them up, they thought that's an acceptable set of circumstances, we don't have to go and complete this because somebody can bail me out the following day."*
>
> **(Teacher, case study 1).**

Most teachers had to emphasise to their students the importance of completing work before lessons. However, many of them managed to integrate this into their existing homework policy, hold the students accountable for completion, or provide them with time outside of lessons in school to complete the work. Some students and teachers noted that requiring a video to be watched, and exercises to be completed before every lesson, created an increased homework workload for students compared to a traditional approach:

> *"I think it does have the potential to improve youngsters' attainment but I think that one would have to be very careful about not overloading them. I think that it has the potential to have a detrimental effect because of the amount of homework involved."*
>
> **(Teacher, case study 2).**

In situations where students were not consistently completing homework, some teachers used the videos in class for students to catch up, often as a whole class. Others found they were 'double planning' for the eventuality that they might have to run a traditional lesson. The existing school homework culture, and the potential for ensuring consistent completion of homework, were both shown to be important factors to consider and plan for before implementing a flipped learning approach.

4.2.5 Teacher identity, role and capacity to manage change

The effectiveness of flipped learning is dependent, at least to some extent, on how teachers perceive their role. For many teachers, the direct instruction element is central to their identity as a teacher. However, in flipped learning, this activity is delegated to a video, which, in the case of this study, was typically produced by someone else. Teachers were comfortable with this change to differing degrees, and emphasised different types of roles and activities as being important to their identity as teachers. Some teachers reported that presenting to the class and explaining new concepts was an important aspect of their identity as a teacher, as was indicated in one interview with a 'comparison group' teacher. This teacher expressed the need to be in control of the explanation of new concepts to the class, not only for reasons of assessment but also in terms of their own identity as a teacher:

> *"From a selfish point of view, I'd like to be the one that was teaching it so that I knew what they'd been exposed to in the first place and I could understand why they didn't get it from my lesson."*
>
> **(Teacher, case study 5).**

Shifting their practice away from doing this is a case not just of considering the practical implications, but also considering how they view their own identity as a professional. For those teachers who see presenting to the class as a central aspect of their professional identity, it may take time before they are comfortable with this shift.

In addition, implementing a flipped learning approach requires a culture shift to a different way of working, and may require ongoing adaptations, at least initially. However, some teachers showed less capacity to adapt and refine the approach until it was successful for a range of reasons, such as having insufficient time and space to reflect, being under pressure to deliver the curriculum quickly or achieve measurable results, not having a sufficient level of authority, or iterative approaches not being compatible with the school culture.

4.3 Schools' future plans

Teachers' valued a flipped learning approach as part of a varied set of teaching approaches. Most of the teachers in case-study schools were keen to continue using a flipped learning approach beyond the pilot phase to introduce new content taught outside of lessons and/or to use digital resources for revision and recapping. There were differences of opinion as to whether these activities should (and could) only take place outside of the classroom. For example, where teachers experienced challenges with learning taking place outside of lesson time, some regarded it as necessary to also provide access to such opportunities in the classroom. In some cases, teachers were keen to explore further the potential benefits of flipped learning for personalised, student-led and collaborative learning.

Three teachers indicated that they would continue with a very similar model to the pilot, in which fundamentally new content would be taught at home through video resources. In two of these cases, the teachers undertaking the pilot were heads of mathematics who planned to roll the approach out systematically across year groups, or the department as a whole. The other was an individual teacher who planned to continue using the approach as part of her practice.

However, teachers in all three of these schools indicated that they did not think flipped learning should be used all of the time or for all topics. Several felt it was more suited to certain topics than others, particularly noting the strength of the on-screen resources for concepts with a visual element, such as angles, shape and space topics. Some noted that the 'novelty' of the approach that motivated students could wear off, and one commented that it was too much

work for the students to watch a video before every single lesson. For those schools rolling out flipped learning beyond the pilot, the plan was for it to be as part of a varied toolkit of teaching approaches. Flipped learning would be selected when the material and different groups of students were suited to the approach, with an aim to create a blended approach of online and offline learning and balance between independent, teacher-led and collaborative learning.

> *"I think that balance – with opportunities to interact with each other and me - is the key, and that flipped learning should be viewed as part of the wider toolkit."*
>
> **(Teacher, case study 2).**

A regular theme in interviews, with both teachers and students, was the potential of using resources designed for flipped learning for purposes of revision. The easily accessible nature and comprehensive coverage of the resources were seen as features that were well suited to revision. In addition, the complexity of some of the Khan Academy materials were felt to make them suitable for revision and extension. Students approaching some of the materials with existing knowledge of the topic would find the complexity and lack of scaffolding less of a barrier and, as one teacher noted, the difference in style and level of challenge could encourage effective re-engagement with material during revision time. Three of the nine schools explicitly indicated that they would use flipped learning materials for revision purposes.

One teacher reported that they felt there was value in using a flipped learning approach throughout a student's studies to demonstrate to them the benefits of revision. Flipped learning could be used to ingrain a culture of revisiting material at home for future recall, a habit that would benefit students in retention and in their revision for high stakes examinations:

> *"I'm hoping to use it as a tool to help them* [students] *see that actually homework helps and revision helps."*
>
> **(Teacher, case study 1).**

Only one school indicated no plans to continue with any aspect of the pilot where teachers had found it challenging to implement due to lack of access to technology, both in school and at home. As a result, students had been unable to complete the homework in sufficient numbers, which meant that teachers had to re-teach content at the start of every lesson. Another teacher stopped the school's involvement in flipped learning part of the way through the pilot, due to students finding the content and structure of the Khan Academy resources too challenging. This teacher planned to implement a flipped learning approach in the future, but intended to use customised instructional videos created by staff in the school. Creating such resources takes time, and they plan to run a further pilot in several months' time once they have developed sufficient resources.

Flipped learning is an approach that all teachers in the pilot thought to be of benefit. This is of little surprise given that they volunteered to take part in the pilot in the first place. However, their views differ on how aspects of the approach would be beneficial to their students in the future. This resulted in a range of plans depending on how their context interacted with the enablers and barriers to flipped learning described earlier. What constituted an enabler for some schools was a barrier for others, and therefore their plans for the future were quite different.

Flipped learning will continue in most pilot schools in some way. As might be expected, teachers will adapt the approach and the use of resources to the context of their school and their students. In some cases, this means using different resources for a fundamentally similar approach, for others it is using resources from the pilot in a different way.

PART 5

Conclusions and 'top tips' for schools

5.1 Conclusions

Nine case-study schools implemented flipped learning in mathematics for around half a term. Most of the case-study schools implemented flipped learning as envisaged, with students undertaking online instructional learning for homework prior to class lessons. Some schools modified this approach and also provided access to the videos as part of lesson activities, including one school that used flipped learning resources as part of a carousel of different activities in lesson time, and another as a session in the computer suite supported by a non-specialist teacher. The research from the pilot has resulted in some important learning that will be useful for other teachers considering using flipped learning in the future.

Qualitative interviews with teachers and focus groups with students in pilot and comparison classes, as well as observations of students in flipped learning and more traditional classes, revealed a number of key enablers of, and barriers to, success. In most cases they were the mirror image of each other. They included:

- The extent to which resources matched the curriculum and ability level and maturity of students.
- Access to technology.
- Existing school homework culture.
- The capacity and willingness of teachers to manage change and take a flexible approach, making ongoing adaptations as needed.
- The extent to which teachers' perceived value in delegating the direct instructional aspects of their role to technology.

In terms of choosing resources that match the curriculum, schools found the mapping documents that were produced to support the implementation of flipped learning very useful. This mapped Khan Academy resources to the English and Scottish mathematics curricula and was used as a reference tool by teachers. Regarding online resources, the Khan Academy resources were recommended for use by pilot schools, but some found the lack of scaffolding of the material unsuitable for the level of their student group. In these cases, they drew on other resources perceived to be more suitable, or had started to devise their own.

In relation to technology, access to laptops, PCs or iPads within school, or by students at home, was an initial barrier for most schools, but creatively surmounted by many, for example by students' use of smart phones or teachers accessing computer suites.

In some schools, students engaged positively with the new approach to learning at home whereas, in others, a lack of homework culture meant that students could not be depended upon to undertake the instructional learning at home within the timeframe of this trial. Where homework was less embedded, some schools adapted their approach to allow students to view the videos at break and lunchtimes, or arranged sessions where students had access to work stations to undertake the work with the support of a non-specialist teacher. Where the flipped learning approach worked best, teachers had the seniority, authority or freedom to make ongoing adaptations to the approach in response to any challenges or barriers that arose.

Where flipped learning was reported to have been implemented most successfully, a range of improvements in teaching and learning and impacts for students had been realised. The time that students spent at home undertaking online instruction resulted in them coming to lessons with a higher level of understanding and knowledge of concepts and topics than in traditional approaches. This freed up time for teachers to spend on a range of other beneficial activities for students, including: practising and applying knowledge and skills; collaborative learning; and independent and student-led learning. Teachers also reported that they had more time to provide individualised support and to gain an understanding of students' preferred approaches to learning. In terms of students' attitudes towards, and progress in, mathematics, the flipped learning approach was reported to have led to the following benefits for some students:

- Increased engagement, enjoyment and satisfaction.
- Increased confidence.
- Increased awareness of their strengths and weaknesses.
- Increased independence as a learner.

In some cases students were reported to have experienced improved progress and attainment, although the short nature of the pilot meant that such observations were limited.

Teachers valued a flipped learning approach as part of a varied repertoire of pedagogical strategies. Most of the teachers in case-study schools were keen to continue using a flipped learning approach, either to introduce new content, or to support revision and recapping of prior learning. In addition, some intended to extend its use to other teachers in the mathematics department. However, there were differences of opinion as to whether these activities should (and could) only take place outside of the classroom. For example, where teachers experienced challenges with learning taking place outside of lesson time, some regarded it as necessary to also provide online access to resources in the classroom. In some cases, teachers were keen to explore further the potential benefits of flipped learning for personalised, student-led and collaborative learning.

5.2 'Top tips' for schools

The study has revealed a number of **'top tips'** for schools considering implementing flipped learning, which are detailed below.

Access to technology

- Access to computers or mobile devices and Wi-Fi at home needs to be considered (and within school if students will also be accessing resources during school time). This may involve some consultation with students to gauge their home access. Consideration may need to be given to use of smart phones or the loan of laptops where students do not have access at home.

Identifying appropriate video/digital resources

- When choosing resources, it is important to check to what extent they match the curriculum and topic. Resources that provide teacher feedback on the activities that students have completed at home and how they have progressed (such as Khan Academy) provide useful feedback to draw on when planning lessons.
- The video and digital resources that are available can be used for both flipped learning and also for revision and recapping content that has already been taught. Material that is less scaffolded and more complex may be more suitable for revision and extension purposes.

Homework culture

- If the school does not have an embedded homework policy that results in a high level of engagement with homework, schools need to institute this before they embark on flipped learning. Otherwise, schools could consider approaches such as opening up access to computers during break or lunchtime, running a session in a computer suite facilitated by a non-specialist teacher or teaching assistant, or enabling students to use the online resources during lesson time. In addition, parents/carers can be involved to help facilitate the process and help ensure homework is completed.

Attitudes and capabilities of students

- The attainment level, maturity and ability to work independently of the student group should be considered. Teachers in the pilot schools tended to target more able students but this does not need to be the case. For students with more basic levels of understanding of concepts and less confidence in working independently, it will be important to consider how their learning is scaffolded to ensure that they are not put off by a lack of appropriate explanation and activities that are of too high a level.
- Where students are less confident and familiar with taking responsibility for their own learning outside of lessons, teachers can consider introducing them to the online resources first in class in a more supported and guided environment.
- In addition, teachers can consider drawing on the knowledge and skills of students who have completed the activities for homework by asking them to lead the start of the lesson or support their peers in pairs or groups.

Managing the change to flipped learning

- Teachers need to be flexible and to adapt their approaches on an ongoing basis in response to reflections on how flipped learning is working, as well as feedback from student progress and attainment data. Teachers will need to plan for how they will capitalise on additional lesson time gained through students coming more prepared. In other cases, they may need to allow time at the beginning of lessons to recap and reinforce home learning or to introduce new content where homework has not been consistently completed or understood.
- Flipped learning should be considered as one approach amongst the wide repertoire of teaching methods that can be used to suit the context and specific content of lessons. Feedback from teachers and students suggests that in some schools it will not be used for every homework exercise as it may not always be best suited to topics and the workload for students could be too high.

ENDNOTES

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11. An indicator of relative deprivation and poverty.
12. The pupil questionnaire showed no noteworthy differences in pupils' attitudes to mathematics and experiences of mathematics lessons before and after implementing flipped learning. The reasons for this may relate to methodological limitations, including: limited and inconsistent time period of the comparison (approximately four to six weeks); small numbers involved; and questions focusing on the use of Khan Academy which were not applicable to all schools.

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