Online, Anytime, Anywhere: Enacting Flipped Learning in Three Different Secondary Mathematics Classes

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Flipped learning is gaining in popularity as a teaching approach in secondary mathematics classrooms. Traditionally seen as the domain of tertiary teaching, flipped learning has a number of affordances that address the challenging demands of teaching secondary mathematics. Enacting this approach requires a reconceptualization of traditional secondary mathematics instruction in that instructional content is assigned as homework before class, providing for more targeted in-class teaching. I describe three different enactments of the flipped learning approach and report on the teachers' and students' experiences of such an approach and the affordances it offers.

Traditionally considered the domain of higher education, flipped learning is increasingly being implemented in secondary school settings. While terms such as "flipped classroom", "inverted classroom" and "flipped learning" are used interchangeably in the literature, Bergmann and Sams (2012), who are credited with conceptualising the approach, prefer the term "flipped learning", which is defined as:

> a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter. (Flipped Learning Network [FLN], 2014, para. 1)

Advocates of the approach report increases in student achievement, success, and engagement (Hamdan, McKnight, McKnight, & Arfstrom, 2013), along with benefits such as increased student-teacher interaction and differentiated teaching for a range of student abilities (e.g., Straw, Quinlan, Harland, & Walker, 2015). The flexible nature of the approach allows students to extend their knowledge "at a pace, in a place and with an educational purpose that suits them" (Ministerial Council on Education, Employment, Training and Youth Affairs, 2003, p. 4), with technology giving them greater control over how, where and when they learn (Australian Curriculum, Assessment and Reporting Authority, 2014). It provides an arguably more engaging alternative to traditional homework practices, which have been perceived by many middle school students as boring, too easy or too hard, or irrelevant (Xu & Wu, 2013). It also has the potential to enhance secondary mathematics practice which has traditionally been dominated by textbook use and externally imposed assessment measures (e.g., Muir & Chick, 2014). Students have shown motivation to engage with the approach, which is important as student disengagement in mathematics is of ongoing concern (Skilling, Bobis, & Martin, 2015). This paper adds to previous research through describing three different enactments of flipped learning in secondary mathematics classes, along with students and teachers' perceptions of the impact of the approach. Specifically, the paper addresses the following research questions: How is flipped learning enacted in three different secondary mathematics classes? How do these enactments impact upon students' uptake of the approach?

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Review of the Literature

Flipped Learning

According to Bergmann, Overmyer and Wilie (2013), flipped learning is characterised as a space where students take responsibility for their own learning, a classroom where students who are absent are not left behind, all students are engaged in their learning, class content is permanently archived for review or remediation, and students receive a personalised education. The Flipped Learning Network (FLN, 2014), established by Bergmann and Sams, distinguishes between a flipped classroom and flipped learning, and advocates that teachers must incorporate the four pillars of FLIP into their practice in order to engage in flipped learning. Table 1 provides a summary of each of the pillars.

Table 1
Overview of Four Pillars of FLIP

Pillar	Characterised by
Flexible environment	Establishment of spaces and time frames that permit students to interact and reflect on their learning as required; flexible spaces which allow students to choose when and where they learn
Learning culture	Giving students opportunities to engage in meaningful activities without the teacher being central; activities are accessible to all students; learning is personally meaningful
Intentional content	Concepts used in direct instruction are prioritised for learners to access on their own; relevant content is created or curated for students; content accessible and relevant to all students
Professional educator	Teacher available to all students for individual, small group, and class feedback in real time as required

It is important to emphasise that flipping a class can, but does not necessarily, lead to flipped learning, and that there is “no single way to flip your classroom… no specific methodology to be replicated, no checklist to follow that leads to guaranteed results” (Bergmann & Sams, 2012, p. 34). While “flipped mastery” may be the ultimate aim, Bergmann and Sams (2012) recommend that teachers gradually make the change to flipping, adapting it to their current practices and contexts.

Enactments of flipped learning and classrooms in the literature include examples of teachers sourcing existing online resources (e.g., Straw et al., 2015), creating video content for teacher-paced instruction (e.g., Muir & Chick, 2014; DeLozier & Rhodes, 2017) and flipped mastery where students set the pace for their learning (e.g., Muir, 2016). In a collective case study involving nine U.K. secondary schools, mathematics teachers were asked to use Khan Academy mathematics resources in their delivery of flipped learning for one year (Straw et al., 2015). Straw et al. (2015) reported a range of benefits including increases in students’ knowledge and understanding, confidence, progress and attainment. Reported challenges included access to technology, identification of appropriate online resources, students not participating in preliminary homework, and teachers and/or students’ preferences for face-to-face, as opposed to remote instruction.

Arguably the most widespread approach reported in the literature requires students to watch pre-recorded video lectures or screencasts prior to attending class and is particularly popular in tertiary settings (e.g., Abeysekera & Dawson, 2015; DeLozier & Rhodes, 2017).

The flipped learning approach may assist with student motivation through developing students' autonomy, competency, and sense of relatedness (Abeysekera & Dawson, 2012).

There are few examples in the literature of mathematics secondary classrooms that have adopted a flipped mastery approach. Muir (2016), for example, described two cases whereby senior secondary mathematics teachers provided a bank of teacher-created video resources for students to access individually and work through at their own pace. Both cases involved courses that were based upon textbooks, with one being subject to externally imposed assessment measures. Muir (2016) found that in contrast with traditional practices experienced in the past, students reported increased satisfaction with the relevancy of materials provided, and greater engagement with, and autonomy over, their learning. Other identified affordances included accessibility, assessment preparation, self-pacing, and optimisation of class time.

Methodology

The research reported in this paper was part of a larger study that employed a mixed-methods approach (Creswell, 2003) to investigate students' and teachers' experiences of flipping the classroom in 10 secondary mathematics classes. Participating students completed online surveys containing a mix of Likert-scale items and open-ended questions, interviews were conducted with teachers and students, and classroom observations were undertaken. Sequential methods (Creswell, 2003) were used to inform the interview questions, allowing more detailed exploration with a few cases or individuals.

Table 2
Overview of Participants in Each Case Study

Enactment	School[1] and context	Grade	Teacher	Students
Teacher paced curated	Keating College (independent metropolitan)	8 (mixed ability)	Mr Shepherd	22
Teacher paced created	Howard College (large independent metropolitan)	12 (Mathematics Methods)[2]	Ms Brown	15
Student paced, teacher created	Fraser College (large metropolitan secondary college)	12 (Specialist Mathematics)[3]	Mr Burns	9

For the purpose of this paper, three cases which illustrate three different enactments of the flipped classroom approach have been selected for discussion. An overview of each case's context and participants is presented in Table 2. Nineteen of the 46 students participated in focus group interviews, which were all audio-taped, fully transcribed, and took approximately 20 minutes. Qualitative data from the interviews and open-ended survey responses were analysed using reflexive iteration (Srivastava, 2009), whereby each sentence in the transcript was coded using open themes. These themes were then analysed

[1] Pseudonyms are used for schools, teachers, and students throughout this paper.

[2] Mathematics Methods is a senior secondary pre-tertiary course that covers topics such as functions, calculus, and statistics and is externally examined.

[3] Specialist Mathematics is considered the top-level mathematics course for Year 12.

to identify evidence related to the four pillars of Flipped Learning (FLN, 2014), along with affordances identified by Muir (2016).

Results

This section has been organised around the three different enactments of the flipped learning approach as experienced in the classrooms of Mr Shepherd, Ms Brown, and Mr Burns. It contains evidence from all data sources as indicated throughout.

Teacher Paced Curated

Lesson observations showed that Mr Shepherd's enactment of the flipped classroom involved an expectation that his students had watched the prescribed videos before class (The majority had). The lessons observed and video tutorials assigned were based around identifying number patterns as part of an algebra unit. Following a brief review of patterning and balancing equations, the majority of the lesson was spent on students individually completing the class allocated exercises from the prescribed textbook. Mr Shepherd's role was to monitor student on task behaviour and assist individuals as required. He occasionally stopped the class to seek feedback on progress, but there was little teacher demonstration or whole class facilitated discussion. In his interview, Mr Shepherd indicated that he generally sourced his video tutorials from 8-10 YouTube channels or regular contributors, and acknowledged that it was sometimes time-consuming to identify appropriate material: "One video might only take about 12 minutes to watch, but it could have taken me an hour or more to find".

The students who were interviewed following the lesson indicated that what was observed was typical in that "we review what we did, what we learnt from the videos and then if we have questions from the video, we ask and then we go over it … We then use the textbook to answer questions based on what we had just learnt for practice" (Chloe). Students generally described the nature of the video tutorials as "a video of someone talking while drawing up the problem and how to solve it using a diagram" (open-ended survey response). Quantitative student data showed that 86% of students had accessed the online tutorials throughout the year and 89% agreed that the tutorials helped them to understand a concept. Only 50% of students agreed that the tutorials were of the right length, and 58% agreed that they watched the tutorials from beginning to end. In terms of engagement, 50% indicated that they found the tutorials boring, yet 75% indicated that the tutorials helped them to better understand the work in class. When identifying advantages of online resources as compared to text books, opinions were mixed, with only 47% of students indicating they preferred online resources. Pragmatic reasons given for this included: "You can search what you want to know", "You can see people do it and it makes it easier to understand", and "You don't have to carry a text book home". Only one response referred to the affordance of being able to replay the video. When comparing the approach with mathematics teaching experienced in the past, interview responses showed that students compared it favourably:

> I would probably prefer to do this … you have more time in class to really understand it … to do the questions and stuff. (James)
>
> You don't go into the class cold, so you know what you're going to be talking about and you know what you're going to be doing. (Albert)
>
> It's good – I'm actually starting to kind of enjoy maths more … I especially enjoy maths when I get it, and when I don't I just hate it to be honest – but I'm understanding it better now. (Chloe)

Other interview comments revealed that for these groups of students at least, it was not important that their teacher prepared the videos, but appreciated that Mr Shepherd "looks for the best ones so they're really good and show understanding of the topic" (James). Along with relevance, students also indicated that videos which were entertaining were particularly effective, including reference to "the lady with the mammoth – it was actually quite funny … and I actually learnt a lot more then" (Chloe).

Overall this cohort of students could see some benefits of flipped learning, but "wouldn't recommend it to everyone … I think it sort of depends on the person and your ability to do it" (Martha). Reasons for this included the perception that "basically you have to teach yourself for most of it" (Arthur) and that "the harder the subject, the harder it might be teaching yourself" (Alison).

Teacher Paced Created

In this enactment, Ms Brown, like Mr Shepherd, also had an expectation that students had watched the allocated video tutorial/s before attending class, with the difference being that the video was prepared, delivered and recorded by Ms Brown. Classroom observations showed that, again like Mr Shepherd, students spent the majority of class time individually completing exercises from the prescribed textbook, which in this case involved the solving of simultaneous equations using matrices. Each lesson observed began with an eight minute "warm-up" where students worked individually from their textbooks. Ms Brown then facilitated students' oral responses to the problems, before briefly revising some of the content from the video tutorial that most students indicated they had watched. The remainder of the lesson (approximately 40 minutes) involved students working individually through allocated questions in the textbook, with Ms Brown individually assisting students who required assistance. Talk occurred between students but there was little whole class demonstration. Students indicated in the interviews that the lessons observed were typical.

At the time of the study Ms Brown had recorded approximately 20 video tutorials, all based upon topics in the textbook and all about an hour in duration. As reported in Muir (under review) Ms Brown preferred to create a video for each topic and then direct students to watch different parts of it, rather than break it up into shorter videos. She used PowerPoint with an OfficeMix add on to record her videos, which students accessed through an emailed link. This was provided to students at least three days prior to class. Student survey data showed that 100% of students had accessed the videos throughout the year and within the last month, and 100% of students agreed that the tutorials helped them to understand a concept and that the tutorials were helpful. Just over half (54%) indicated that the tutorials were of the right length, with only 38% indicating that they watched all of the tutorials from beginning to end. Interestingly, 77% indicated that they found the tutorials boring, yet 85% of students indicated that they accessed all or most of the video tutorials that were made available. In terms of comparisons with the text book, students' responses indicated that they viewed them as complementary, rather than a replacement, for either the textbook or the teacher:

> You can access the videos and information from anywhere. (open-ended response, survey)
>
> They are presented in different ways – if you don't understand the book, watching another person explain the concept can help you to gain a better grasp of the ideas and skills needed. (open-ended response, survey)
>
> For me, if the teacher said, watch this video as compared to doing 20 questions in the text book, I would do the video – it's more appealing. (Anna, interview)

When asked to compare the approach with that experienced in mathematics lessons in the past, the following comments were illustrative of students' perceptions:

> We didn't do questions like this, not all the time, like we used to sit and listen, but now she's doing more questions in class so that gives you more time with her one on one if you have questions, whereas I can remember some other topics, we would just sit and listen, and … we wouldn't do as many questions like we were doing today. (Hayley, interview)

> It's better having the video and watching it at home and being able to come and ask the teacher if I am still unclear about how to do something or a particular concept … I think it's better than last year where we would go through the book and rather than have lengthy explanation in class, it's better to have an idea before you get to class. (Anna, interview)

In their interviews, students identified a number of affordances with the approach, including reference to self-pacing, accessibility and convenience. Helen, for example, appreciated the autonomous nature of the approach, stating that: "You can always go back and view them, not like last year when you had to continuously ask for help".

Interestingly, students varied in their perceptions as to whether or not it was important that Ms Brown had prepared the videos. Abigail, for example, stated that "You understand it better when it's someone you know… and they can explain it again in a similar way in class if they have to". Anna, however, commented that:

> I don't think it's really important who does it – whether one teacher does the video or the entire maths faculty… but what's good about a teacher from school doing it as opposed to Khan Academy is that they know what the curriculum is and know what's important to focus on… The few times I did that [looked up on Google] it was extremely lengthy and only a few relevant points so it is easier having Ms Brown give us the videos – it's a lot more concise and relevant to what we want.

The above comment indicates that a sense of relevance should be considered as a motivator for students' engagement with the videos, along with competence, autonomy and relatedness (Abeysekera & Dawson, 2012).

Student Paced, Teacher Created

At the time of the study, Mr Burns had created 193 video tutorials for his students to access that covered the requirements of the Grade 12 Specialist Mathematics course. Topics in the course included conic sections, complex numbers, and differential equations. Typically students would access the videos for each topic, attend class where they would individually work through associated exercises in the textbook, then sit a test to demonstrate mastery of the topic. As with Ms Brown's approach, students were expected to access the video tutorials and complete related textbook exercises in class, but in Mr Burns' class, the students were all working at their own pace and on different topics. While some class discussions and demonstrations were observed, students tended to "opt in" according to relevance, and the majority of class time was spent on individual work, with Mr Burns providing personal assistance when required.

Student survey data indicated that 100% of Mr Burns' students had accessed his videos throughout the year, and most of the students had accessed them within the last month. Interestingly one student revealed in the interviews that he no longer accessed the videos as he felt that he already had a firm understanding of the topics covered. Other survey data showed that 86% of students agreed that the tutorials helped them to understand a concept, with 100% finding the tutorials helpful. Similar to Ms Brown's students, 29% of Mr Burns' students indicated that they found the tutorials boring, yet interview data showed they appreciated Mr Burns' dedication to producing the videos and his sense of humour.

Comparisons with the textbook revealed that, like Ms Brown's students, these students tended to view the approach as complementary. Open-ended survey responses included: "Online resources often give harder examples and more variety", and "Using online resources makes it possible to learn more information than what is possible in a textbook alone. A textbook can also be difficult to comprehend sometimes". Comparisons with past traditional mathematics instruction involved reference to affordances such as a capacity to focus and accessibility (Muir, 2016). Chris (Grade 12), for example, stated that:

> There's no interruptions [at home] whereas in class there are so many interruptions … he might be halfway through an explanation and then somebody interrupts … if you get distracted, [at home] you just pause the video and come back to it.

Mr Burns also identified similar affordances, along with the autonomous nature of the approach:

> A couple of months ago… one of the girls in the class came to me and she said… I've got to watch those videos three or four times before I understand what's going on and I thought to myself, gee I only teach it once and if I only taught it once, she wouldn't have got it.

As with the other enactments, students in Mr Burns' class were ambivalent about the importance of the teacher preparing the videos. Again students emphasised that the videos needed to be relevant and acknowledged that it was helpful having access to Mr Burns in class, having watched his videos beforehand. Mr Burns, however, was adamant about the importance of creating the videos:

> The students relate [to me] I think better than they do to somebody talking about a video that may contain 40 or 50% of what they are looking for; the videos they are looking at now contain 100% of what they are looking for so it's more important in that respect… I think it's very important… because you still need that teacher/student relationship and that works for the student and that works for the teacher. I can give them 20 or 30 videos to look at on a particular topic that are on YouTube but whether they'll get anything out of it compared to having me do the video and talking about them at their level… I know who they are and what they're doing, I think makes a big difference. I think it really is important that the teacher does the video, it really is.

Discussion and Conclusions

In terms of enacting the pillars of flipped learning as depicted in Table 1 (FLN, 2014), while all teachers demonstrated aspects of these in varying degrees, Mr Burns' students were arguably experiencing flipped learning rather than a flipped classroom. Both Mr Shepherd and Ms Brown were definitely providing students with intentional content through either selection or creation of relevant and appropriate videos, and both made themselves available as a professional educator. Aspects of the learning culture were present in that the teacher was not always central to the learning and all activities were accessible to students. Classroom observations, however, showed that students' experiences were centred on individual textbook exercises which did not seem to be especially personally meaningful. Similarly, while the homework environment may have been different, the classroom space was not a flexible environment in terms of students choosing where and when they learned. Mr Burns' students, however, were experiencing a flexible learning environment through having autonomy over their learning and self-pacing their progress through their course. Intentional content was provided through the bank of videos that students could access where and when it suited them, while still having access to a professional educator. It appears that despite the different enactments, students in all three classes were willing to take up the approach and compared it favourably with traditional forms of teaching as experienced in the past. While it is important to acknowledge that the cohort of students taught by Ms Brown and Mr Burns were enrolled by choice in their classes and arguably strongly motivated to achieve, Mr Shepherd's class arguably represented a more "typical" Grade 8 class and also reported favourably on the approach.

In conclusion, this study has contributed to the field of flipped classroom research through its focus on three different enactments of flipped learning within secondary mathematics classrooms. The results show that while the flipped classroom may be enacted in various forms and to varying degrees, student and teacher perceptions indicate that the approach has merit, particularly in terms of complementing existing practices. The study has practical implications for teachers, educational providers and students who may be teaching and learning within the constraints of a traditionally imposed curriculum and delivery method.

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