It's More Than the Videos: Examining the Factors That Impact Upon Students' Uptake of the Flipped Classroom Approach in a Senior Secondary Mathematics Classroom

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Senior secondary mathematics in Australia is generally characterised by a challenging prescribed curriculum, textbook usage, high homework expectations and externally imposed assessment tasks. An increasing number of senior secondary mathematics teachers are incorporating a flipped classroom approach into their teaching as a means of addressing this challenging teaching space. This paper looks at a case study undertaken with a Grade 12 class where the teacher utilised a flipped classroom approach to teach Mathematics 2. The results showed that it was the holistic approach and commitment and dedication of the teacher that primarily influenced students' uptake. The study has implications for other teachers who may be considering implementing a flipped classroom approach, particularly in terms of the commitment required.

With its focus on high stakes assessment and mandated syllabus, teaching senior secondary mathematics is a challenging task. In order to meet the demands of a crowded syllabus, some senior secondary mathematics teachers have adopted a flipped classroom approach in their mathematics classrooms. This approach, which has been credited to Bergman and Sams (2012), typically involves the recording and narration of video tutorials, which replace 'traditional' homework practices and frees up class time for more focused teaching, rather than direct instruction. Advocates of the approach report that it allows for differentiated teaching for a range of student abilities, increased student motivation and autonomy and increased student-teacher interaction (e.g., Abeysekera & Dawson, 2015; Bergman & Sams, 2012; Muir, 2016). Despite maintaining that "it's not about the videos" (Bergman & Sams, 2012, p. 95), but rather the increased class time the videos can facilitate, much of the reported research in the area has focused on the affordances of the approach (e.g., Straw, Quinlan, Harland, & Walker, 2015) and often in the context of tertiary settings. Some authors have argued that it's more about good teaching practice that incorporates constructivist principles (e.g., Strayer, 2012), leading one to question as to whether or not it's just 'good teaching'. The authors' previous work has examined the affordances of the approach in terms of creating conditions that motivate students to engage with the approach. In common with Abeysekera and Dawson's (2015) motivation factors, Muir (2016) found that a sense of relatedness with the teacher was a strong motivating factor for students to engage with the approach. This paper specifically examines the role of the teacher in implementing a flipped classroom and the impact this has on motivating students to engage with the approach. Classroom observations, teacher and student interviews were conducted in order to answer the following research questions: How is the flipped classroom experienced in a senior secondary mathematics class? What impact does the teacher have on students' uptake of the approach?

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Review of the Literature

The terms flipped classroom and flipped learning are not interchangeable, and according to the Flipped Learning Network (FLN, 2014), flipped learning only truly occurs when 'four pillars' are applied in practice. These four pillars are flexible environments, learning culture, intentional content and professional educator. Of particular relevance to this paper is the role of the professional educator, where the instructor is described as an active observer who offers timely and relevant feedback and assessment, connectedness, reflection and revision, and who intentionally designs content to promote critical and higher-order thinking (FLN, 2014).

In a recent synthesis of research into mathematics flipped classrooms, Lo, Hew, and Chen (2017) examined classroom studies in which pre-class instructional videos were provided prior to face-to-face meetings. They examined the types of out-of-class and in-class instructional activities used, the effect of flipped learning on student achievement, the participant perceptions of flipped classroom benefits and the main challenges of flipped classroom implementations. Along with highlighting the limited research undertaken in secondary school settings and Australia, their synthesis showed that the top three most frequently reported benefits of flipped learning were instructor feedback, peer-assisted learning and more in-class time to apply concepts during activities (Lo et al., 2017). On-demand accessibility of video lectures and preparing students for class were also reported as positive benefits, along with the use of differentiated instructional activities. The two major challenges reported with implementing the approach were the students' unfamiliarity with flipped learning and the instructors' significant start-up effort. Other studies have reported similar findings (e.g., Muir & Geiger, 2015; Straw, et al., 2015), with student reports indicating that in contrast with traditional practices experienced in the past, the flipped classroom approach provided them with an increased level of satisfaction with the relevancy of materials provided and greater engagement with, and autonomy over their learning (Muir, 2016). Affordances such as self-paced learning (Goodwin & Miller, 2013; Muir, 2016), improved student-teacher interaction (Goodwin & Miller, 2013) and accessibility (Muir, 2016; Straw, et al., 2015) were also reported as positively influencing students' motivation to engage with the approach.

Theoretical Framework

Engagement, Motivation and Individual Needs

Engagement is a multi-faceted concept that is typically described as including behavioural, emotional and cognitive aspects (Fredericks, Blumenfeld, & Paris, 2004). Behavioural engagement concerns involvement in learning and academic tasks, while cognitive engagement involves behaviours such as being strategic or self-regulating, and use of learning strategies such as rehearsal, summarising, and elaboration to remember, organise, and understand the material (Fredericks, et al., 2004; Corno & Mandinach, 1983). Emotional engagement refers to students' affective responses and includes feelings and attitudes such as interest and anxiety (Fredericks, et al. 2004). Reeve (2013) identified a fourth dimension of engagement: agentic engagement, which involves students' self-learning with the teacher providing instructional support. Teacher support has been shown to influence behavioural, emotional and cognitive engagement (Fredericks, et al., 2004), with teacher involvement being positively associated with engagement, and that in turn, higher student engagement can result in great teacher involvement (Skinner & Belmont, 1993). Student engagement has

also been shown to increase when teachers support autonomy and cater for students' needs for competence and relatedness, which is more likely in classrooms where teachers and peers create a supportive environment (Fredericks, et al., 2004). The three basic needs of competence, autonomy and relatedness form the basis of self-determination theory (Ryan & Deci, 2000), and have been shown to be catered for in the context of a flipped classroom approach (Abeysekera & Dawson, 2015).

Methodology

The study used a mixed-methods approach (Creswell, 2003) to investigate the enactment of a flipped classroom in a Grade 12 senior secondary class, taught by Mr Simmons (pseudonyms used for school, teacher and students throughout). Data were gathered from a student online survey, classroom observations and teacher and student focus group interviews. The online survey consisted of 42 Likert scale items that required students to indicate levels of agreement and 10 open-ended questions. Likert scale items included general statements about accessing online resources (e.g., 'I have used online tutorials/videos not prepared by my teacher to help me with my mathematics this year'), pragmatic items about usage (e.g., 'I usually watch all the tutorials/videos from beginning to end'), and motivational aspects (e.g., 'I would not watch the tutorials/videos if my teacher had not prepared them'). Twenty six of the 27 students in the class completed the online survey approximately two weeks prior to the classroom observations to help inform the focus group interviews. A total of 20 students participated in eight focus group interviews which were semi-structured in nature, of 20-30 minutes duration, audio-taped and fully transcribed. An audio-recorded semi-structured interview was also conducted with Mr Simmons following the classroom observations. Quantitative data from the Likert scale items were analysed using descriptive statistics to report on percentage level of agreement with the statements. Open-ended survey responses and interview transcripts were analysed using reflexive iteration (Srivastava, 2009), whereby each sentence was initially open-coded and common themes identified. These themes included, but were not restricted to, affordances of the approach as identified in the literature, and evidence of meeting students' needs of autonomy, relatedness and competence.

Context

The case study school 'Barton Anglican School' is a co-educational independent K-12 Anglican School with a student population of 1600. Mr Simmons had taught at the school for approximately 10 years, and this was his second year of both flipping his mathematics class and teaching this cohort of students. He was currently teaching Year 12 mathematics 2 unit, which was a Higher School Certificate (HSC) subject and included topics such as plane geometry, integration, differential calculus and probability (NSW Board of Studies, 2014). The lessons observed were from Topic 9, 'Applications of Series' and involved calculating compound interests and superannuation tables.

For each topic Mr Simmons would prepare a 'roadmap' (see Figure 1) which included notes for each week, readings, videos and individual student directions and was accessed through the school's intranet system. Students could work individually through the roadmap for each topic. Typically, each week would require students to watch one or more videos, complete exercises from the textbook and complete quizzes or practice exam questions. The video tutorials would be watched before class, with class time spent individually working through exercises. During class lessons Mr Simmons would individually work with students,

occasionally instruct whole class on specific problems or applications and often tutor small groups who were at a similar level or having common difficulties.

Date	Work covered	Homework	Homework problems
1 May	Devices and headphones in class tomorrow HY practice paper solutions distributed. Mark them, marks to tr. Venn diagrams pp 9-10	Cambridge (12) Ex 8D Q 1,4,7,10,13 Mark 2010 HY paper Video on population estimation (capture-recapture) p. 11 (5 mins)	Quentin Q 12 Callum Q 12, Q6C Liam Q 12 Q 12 Travis Q 12
3 May	p. 17 example link Parabolas follow up: Jim, Gavin	Notes p18 Q2, 4-12 Notes p19 Q1-4, 8, 9. Videos pp20-22 Multi-stage events and product rule. Page 22 is heavy going. Approach with a fresh mind and you may need to watch it more than once. (total 34 minutes)	Michael p 19 Q 4 Travis p 19 Q4

Figure 1. 'Roadmap'.

Results and Discussion

Experiences of the Flipped Classroom

In order to understand how the flipped classroom was implemented and experienced by the participants in this study, data relevant to the enactment of the approach in practice was extracted from observations, survey and interviews. In the lessons observed, students came to class having watched the allocated video tutorials, usually the night before, and worked through the lesson following a plan projected on the whiteboard. Leo summed up a typical lesson as follows:

> … what we normally do is he has an overhead where he shows us a couple of pages of the topic and he'll kind of work through a couple of examples with us and then do a proof, talk through the formulas and how it all works so we get a greater understanding of it and then after that we go through and then work on some questions on our own to see if we can do it by ourselves and then just ask him questions as he kind of goes around the classroom and just making sure everyone's down pat with [everything].

Classroom observations showed that it was evident that students had come to class prepared, having watched the video prior and were able to start work immediately. There was a classroom culture of expectation that students would watch the video, with class work dependent upon this:

> … a lot of it is very dependent on watching the videos, because if 25 of us watch the video and there's like three kids who don't he's not going to spend a whole other 25 minutes explaining it to those kids … when he's already produced [the video] [Quentin]

Mr Simmons explained that in contrast to the past, more class time was devoted to helping individuals and that the videos also allowed for greater focus and less repetition:

> I'm spending a lot less time delivering content in class and I'd like to think with that time I've gained I'm able to spend that in hopefully a quality way in helping students. Like this morning for example the help was mainly individual but there was a little bit of group stuff, particularly the group at the front who were all stuck on the same thing and I thought it was efficient to do it all together.
>
> [students are] able to go back and relearn content, with it not always being up to me. So if a student says I've forgotten how to do quadratic equations by substitution I can say "there's a video for that, go back and watch it."

Although it was not possible to observe students' interaction with the videos at home, the interviews provided an insight into their use. All students interviewed indicated that they set aside time to watch the videos, away from distractions, and that it was not a passive exercise. The following quote from David was typical of the responses received:

> I do it at my desk in my room, with the worksheet in front of me, copying it down and you've usually got to rewind it a couple of times and think of what is assumed knowledge and revise a little bit on that … and if I had difficulty understanding it I'd write that down and either email Mr Simmons or ask him the next day or I'd try to do questions and then go back to the video to see if I did it right or not.

In the survey, 93% of students agreed or strongly agreed that they usually watched the videos from beginning to end, with 92% of them agreeing that they were about the right length, despite some being up to 35 minutes long.

Motivations for Engaging with the Approach

Data from the survey and interviews indicated that students were able to identify a number of affordances with the approach which influenced their motivation to watch the videos, come to class prepared and participate in class. While students certainly believed that the approach assisted them academically and cognitively, it seemed they were particularly motivated to watch the videos and engage in class because of their teacher. Over two years, Mr Simmons had developed a strong relationship with this cohort of students, making a *sense of relatedness* particularly influential on their motivation to engage. The survey results showed 100% agreement with the statement, 'I relate well to my teacher', 96% of students agreed or strongly agreed that they were 'motivated to watch the videos because my teacher prepared them' and 89% agreed that Mr Simmons 'enjoys making the videos'. Interview data showed that there were nine direct references to Mr Simmons' dedication, including statements such as "I don't know a teacher who is as dedicated to their class or each of their classes like Mr Simmons" [Grant] and "I'm sure the other guys here can say the same, but I don't think I've known a teacher who puts in as much work with his students than Mr Simmons has" [Chris]. The students genuinely expressed an appreciation for the work involved with the approach, with at least 10 students emphasising this, as illustrated by the following interview responses:

> It would be unfair not to show respect for him when I know that [he] is putting in that work because he wants me to do well … I want to put that work back in [Leo]
>
> He's always one of those teachers that you want to well for just because he puts so much time and effort into you and he wants you to succeed [Michael]

Mr Simmons was quite modest about his role and emphasised that it was "… not about me. It's about the content and trying to explain the content as best I can". He did not include an image of himself in his video tutorials or attempt to make them entertaining or humorous. He was, however, meticulous about the quality of the videos in terms of being relevant,

accurate and helpful. For example, he cited a recent example which required him to re-record a video because he was not happy with it:

> Sometimes I realise I've made mistakes .... I did one recently where I recorded a whole video one night at school and it was about [how] to use geometric series to simplify a recurring decimal. So if you've got 0.232323 how you'd write that as a sum which you can then use series techniques to write as a fraction. I did the whole thing - it was a 15 minute video - got home and I thought I've done it wrong. That was not the best way to explain it. So I came back in the next day and redid it.

In the survey and interviews, students were specifically asked about their use of other online videos and tutorials and whether or not they thought it was important that the class teacher prepared the videos. In response to the statement 'I would not watch the tutorials/videos if my teacher had not prepared them', only 40% of students agreed and 33% were undecided. Open-ended survey responses indicated that several students had accessed online videos through Khan Academy with the general consensus being that while some maybe useful, the material prepared by their teacher was more specific and relevant to their learning, and they had the opportunity to follow up in class the following day. Further probing in the interviews revealed that while students were open to other teachers preparing the videos, "they'd need to be of the same standard as him … I'm not sure if there is someone like that …" [Grant] and "… it kind of builds a relationship between teacher and student being able to have the video there, but also still being in class with him. I guess that's important because if it was someone else making the video, there'd kind of be a disconnect" [Mitch].

Students also reported that Mr Simmons' flipped classroom approach helped developed their *sense of autonomy*. The autonomy to go at one's own pace in terms of "not having to wait for others" [Michael] and "allowing you to take your time with stuff that you may need to focus more on rather than having to get through it at the same pace as everyone else" [Grant] was referred to frequently in the interviews. The pause and rewind affordance of the videos also promoted autonomy in that:

> I can pause at points if I don't get something. I can rewind – I can do basically whatever I want with the video in terms of manipulating the order of instructions … skipping bits, going back … that you can't really do in a classroom if the teacher's teaching you … I think it gives you a lot more independence, a lot more freedom to actually learn at your own pace and get the stuff that you may feel less confident with [Grant]

Grant's comment also shows the link between the *sense of autonomy* and *sense of competence*. As previously mentioned, both the teacher and the students felt that it was important that the watching of the videos were not passive, but involved interaction in terms of note-taking, working through examples and recording questions for later follow up. Directions were often given which recommended that students pause the tutorials at certain points to work through particular examples:

> There's heaps of occasions in the videos where Mr Simmons will say pause here if you want to work this out yourself and you can do things yourself based on how you might think – it gives you the tools to work things out yourself … you definitely have to interact and work with it [Michael]

Together with recognising the time and effort Mr Simmons put into the videos, students also recognised that the content of the videos was designed to help them learn and increase their competence. Ben, for example, stated that "There's never been one where I've gone in and watched a video and gone wow, that was disappointing or I don't understand – I come out of every single video saying OK, I know what I need to do tomorrow in class".

Mr Simmons not only prepared content that was relevant and specific to their course, he also carefully planned and structured the order in which content was presented. Quinn, for

example, stated that "he plans it all out so that you watch the video at the right point in the course, and he makes them when he thinks we're going to need them"; another strategy which catered for students' *sense of competence*.

The flipped classroom approach has been criticised for its seemingly strong emphasis on procedures, however the students in this class were confident that understanding and application was also emphasised. Grant, for example, stated that:

> It's a bit procedural, but you do end up getting a good idea of how the actual theory works because at the start he explains it to you … he'll usually spend time explaining the theory behind using xy, ab, … in the actual equation. Then after he's explained all that and how to do in that way, then we'll move onto a couple of different examples to show how you can apply it to different problems.

The survey results also indicated students thought understanding was important. There was 100% agreement with the statements: 'The tutorials/videos helped me to understand a concept' and 'My teacher wants us to understand the work, not just memorise it'.

Overall the teacher and students were advocates of the approach, particularly in comparison with more traditional approaches experienced in the past. In the survey, 93% of students strongly agreed or agreed that they 'Prefer to learn mathematics using this approach', with 100% agreement that they would recommend the approach to others. Students cited the video tutorials as being both complementary but also preferable to the text book in that "it makes it easier to understand when the content is difficult, as it is being explained by someone who understands the content already" and "the videos created by my teacher sometimes include better methods of solving problems that aren't included in the textbook" (open-ended survey responses). While they did not see the videos as replacing their teacher, they cited advantages such as having a resource readily available and revisiting concepts, as affordances conducive to their learning.

Conclusions

The results showed that the enactment of a flipped classroom approach in this study consisted of a carefully designed program where students were provided with clear directions, relevant resources, and dedicated teacher support. While acknowledging that the students in the study elected the subject and wanted to achieve good results, the approach adopted by Mr Simmons also facilitated their motivation and engagement. This required a considerable time and dedication. The students consistently reported that they had developed a strong *sense of relatedness* with Mr Simmons, both in terms of their relationship with him and his ability to provide them with content and resources that were relevant and accessible. Consistent with previous findings (e.g., Muir, 2016), many of these students reported that they were motivated to watch the videos because of all the time and effort put in by their teacher, thus feeling a sense of obligation to 'reward him for his efforts'. References made by students to relevance and understanding also provided evidence that they were cognitively engaged (Fredericks, et al., 2004) with the materials, demonstrated behaviours such as being strategic or self-regulating, and used learning strategies such as rehearsal, summarising, and elaboration to remember, organise, and understand the material (Fredericks, et al., 2004; Corno & Mandinach, 1983). The autonomous nature of the approach also facilitated cognitive engagement and agentic engagement (Reeve, 2013) as students were involved in self-learning, with teacher instructional support.

Senior secondary mathematics is a challenging domain where teachers are required to teach complex mathematical topics, follow a set curriculum and prepare students for externally imposed high stakes assessment tasks. The flipped classroom approach enacted in this study has demonstrated how a teacher can adapt traditional classroom instruction to

maximise opportunities for students to be in control of their learning. This has practical implications for other teachers in similar contexts who may consider adopting such an approach, with the understanding that it can require a considerable commitment of time on behalf of the teacher, yet it seems the benefits are worth the investment. The paper adds to the limited research on flipped mathematics classrooms in secondary settings through its focus on the role of the teacher, rather than the pragmatics of video production, and through listening to the students' voices in identifying the factors which motivated them to engage with the approach.

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