

# No more ‘What are we doing in maths today?’ Affordances of the Flipped Classroom Approach

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Teachers of senior secondary mathematics are required to contend with a number of challenges including covering the prescribed curriculum, differentiating the content for a range of learners, and preparing students for externally imposed assessment tasks. The flipped classroom is gaining in popularity as an approach that can be used to address these challenges. This paper provides a framework that can be used to interpret the affordances of a flipped classroom within the context of teaching secondary mathematics and the motivational factors that influence the uptake of the approach. Data analysed through the framework showed that students believed that the approach enabled them to have autonomy over their learning and achieve their goals. The study has implications for senior secondary teachers and students, particularly in terms of meeting the challenges of curriculum coverage and preparation for externally imposed assessment tasks.

Traditionally the domain of tertiary education, the flipped classroom approach is gaining popularity in secondary classrooms. The accessibility and affordances of digital technologies have facilitated the uptake of the approach, through allowing teachers to record and narrate screenshots of worked mathematical problems, create videos of themselves teaching, or curate video lessons from internet sites such as Khan Academy (Hamdan, McKnight, McKnight, & Arfstrom, 2013). Although enactments of the flipped learning approach varies in practice, typically direct instruction is moved from the classroom for students to access independently, usually through the use of videos. Class time can then be optimised with more targeted and individual instruction happening. Proponents of the approach advocate that it allows for differentiated teaching for a range of student abilities, greater student motivation and increased student-teacher interaction (Bergman & Sams, 2012). The success or otherwise of the flipped classroom, however, has not been extensively researched and remains under-theorised (Abeyseker & Dawson, 2015). Previous research has typically focused on higher education settings (e.g., Abeyseker & Dawson, 2015; Strayer, 2012) or commissioned reports (e.g., Straw, Quinlan, Harland, & Walker, 2015; Yarbrow, Arfstrom, McKnight, & McKnight, 2014). The research that has been conducted, however, is promising and indicates that flipped classroom approaches can promote student achievement, success, engagement (Hamdan et al., 2013) and positive affective outcomes for students (Muir & Chick, 2014). This paper adds to previous findings through the documentation of two cases where the teachers and students were involved in mastery of the curriculum content, afforded by the flipped classroom approach. Specifically, this paper aims to answer the following research questions: What are the affordances of a flipped classroom approach in the teaching of senior secondary mathematics? What are students’ motivations for engaging with the approach?

The link with engagement is an important one as there is continued concern in Australia and internationally over the lowering levels of engagement with mathematics (Attard, 2010). Middle school students’ attitudes towards, and interest in, science and mathematics continues to decline (Department of Education and Early Childhood Development, 2009) leading to less uptake of courses requiring specific levels of mathematics. Bergman and Sams (2012, p. 20) argue that the flipped classroom “speaks the language of today’s students” with the approach

taking advantage of students' propensity to be online. It also allows students to extend their knowledge "at a pace, in a place and with an educational purpose that suits them" (MCEETYA, 2003, p. 4), with technology giving them greater control over how, where and when they learn (ACARA, 2014).

## Theoretical Framework

### *The Flipped Classroom and its affordances*

Preferring the term, 'flipped learning', Bergmann, Overmyer, and Wilie (2013) characterise it as: a means to increase interaction and personalised contact time between students and teachers, a space where students take responsibility for their own learning, a classroom where students who are absent do not get left behind, class content is permanently archived for review or remediation, all students are engaged in their learning and students receive a personalised education. According to Bergmann, et al., (2013), the real potential of flipped learning lies in the provision for students to achieve mastery of topics as they are able to self-pace their learning. The ultimate aim is for students to access video resources when ready, work through the resources at their own pace, and demonstrate mastery through the completion of assessment tasks.

To date, most of the empirical research related to the practices of the flipped classroom approach has taken the form of small-scale studies conducted in higher education settings (e.g., Strayer, 2012) or large-scale surveys (e.g., Flipped Learning Network (FLN), 2015). In a large-scale survey (n=521 865) conducted as part of Speak Up Online (FLN, 2015), for example, 59% of students in grades 3-12 agreed that a flipped classroom approach helped them to learn at their own pace and 50% agreed that they exercised more control over their learning. The survey also found that 32% of teachers were using on-line sourced videos in their teaching, while 29% of teachers produced their own videos. In a recent study conducted by Straw et al., (2015), teachers reported a range of benefits for teaching and learning practices. These included more time for practising and applying knowledge and skills, independent and student-led learning, individualised support and increased understanding of students' learning styles. They also reported that students showed increases in engagement in learning, knowledge and understanding, confidence, progress and attainment. Challenges identified included access to technology, identification of appropriate online resources, some lack of participation in preliminary homework and teacher and/or students' preference for face-to-face as opposed to remote instruction.

### *Motivation, self-regulation and the flipped classroom*

Motivation can be defined as "the willingness to attend and learn material in a development program" (Cole, Feild, & Harris, 2004, p. 67) and is closely linked with engagement. It has also been strongly linked with self-regulated learning and according to Pintrich and De Groot (1990), contains three key components: an expectancy component, which includes students' beliefs about their ability to perform a task; a value component, which includes students' goals and beliefs about the importance and interest of the task; and an affective component, which includes students' emotional reactions to the task. In other words, students' motivation is related to their beliefs about whether or not they can perform the task and whether or not the task is worth performing. This has synergies with Abeysekera and Dawson's (2015) research that identified five components of the flipped classroom which increased students' motivation: sense of competence, sense of relatedness, sense of autonomy,

tailoring to expertise, and self-pacing. In their theoretical model, students develop a sense of competency through a belief that they can perform a task, are motivated to perform the task if they can relate to it as being important and interesting, and are more likely to complete the task if they have a sense of autonomy or belief that they are responsible for their own learning. The framework was developed within a higher education setting, and was untested by the researchers. The research discussed in this paper builds on this framework through re-conceptualising the motivational factors and situating them within the particular affordances that were identified by the case study participants.

## Methodology

The research reported in this paper was part of a larger study which employed a mixed-methods approach (Creswell, 2003) to investigate the affordances of a flipped classroom approach in 10 senior secondary mathematics classes. Online surveys containing a mix of Likert items and open-ended questions and interviews were conducted with teachers and consenting students. Sequential methods (Creswell, 2003) were used to inform the interview schedule, allowing more detailed exploration with a few cases or individuals. The questions asked through the surveys and interviews were aimed at eliciting participants' experiences with their mathematics classes and their perceptions of the benefits or otherwise of the approach. The cases reported on in this paper involve two classes where the teachers were flipping their mathematics classes using a mastery approach. In both cases, the teachers created their own bank of video tutorials that were available for access from the respective schools' learning management systems. The students would view the tutorials out of class, complete individual work from the prescribed text in class, sit a test to demonstrate mastery of a topic and then move on to the next topic. As students worked through the material individually, there was minimal whole class teaching.

The first class selected was taught by Mr Hill<sup>1</sup>, a fully qualified mathematics and science teacher, who had been flipping his mathematics class for three years. He was teaching at a co-educational metropolitan secondary college in Tasmania, which had an enrolment of just over 500 students. The class contained a mix of 27 students, some of which were studying the mainstream Grade 10 curriculum, while others were studying 'extended maths' as a pathway to study pre-tertiary mathematics in the following year. A prescribed textbook was used to guide decisions about the sequence and approach to teaching mathematics topics, which included algebra, functions and their graphs, calculus, and probability. The second class, consisting of nine Grade 12 students, was a Specialist Mathematics class, taught by Mr Burns. Mr Burns was also a fully qualified mathematics teacher, with over 20 years of teaching experience. He was teaching at a large co-educational metropolitan secondary college in Victoria with an enrolment of almost 1500 students. This was his first year of flipping the classroom, and at the time of the study he had created 193 video tutorials for the students to access that covered the requirements of the course. Specialist Mathematics is considered the most advanced mathematics course in Australian secondary schools and includes topics such as conic sections, complex numbers, differential equations, vector calculus and mechanics.

The procedure for all cases involved completion of an online survey, teacher and student interviews and class observations. The survey was completed before the student interviews and responses were used to inform the questions asked in the interviews. Six students agreed to participate in five focus group interviews, which were audio-recorded and transcribed, and took approximately 15 minutes. The teacher interviews were conducted individually, prior to

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<sup>1</sup> Pseudonyms are used throughout for teachers and students.

the classroom observations and student interviews. They were also audio-recorded and transcribed and took approximately 20 minutes. Due to space constraints, only teacher and student interview data is reported in this paper.

Qualitative data from the interviews were analysed using reflexive iteration (Srivastava, 2009) whereby each sentence in the transcripts was coded using open themes. These were then compared with the five categories as identified in Abeysekera and Dawson’s (2015) framework. Although many comments could be classified into one or more of their five categories, other categories also emerged, with some being more affordances rather than motivations. The author was also interested in separating motivational factors from affordances. When coding for motivational factors, the author looked for instances of starting phrases, such as “I like ...” or “I want ...”. Identified affordances included phrases such as “it helps you ...” and “it lets you ...”. As an illustrative example, the comment, “They are allowed to move ahead, they can go any speed they want” [Mr Burns] was coded as being affordances of ‘self-pacing’ and ‘differentiation’. The author looked for at least three occurrences before creating the five motivational factors and nine affordances identified in Figure 1. The central placement of the motivational factors show they are integral to accessing the affordances identified in the outer circle. These aspects are elaborated on in the Results and Discussion section of this paper.

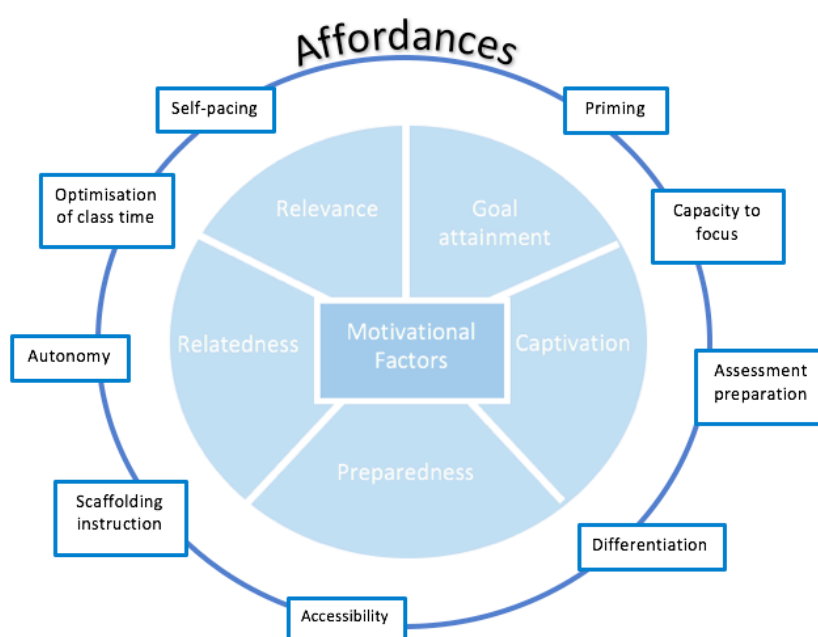


Figure 1. Motivational factors and affordances of the flipped classroom

## Results and Discussion

### *Motivational factors*

In the interviews the students were asked to identify any advantages of online resources over the use of a textbook or asking the teacher, how and why they used the resources, whether or not they would recommend the resources to others, and how the approach

compared with their past experiences of mathematics lessons and homework. *Goal attainment* was the dominant motivator, probably attributable to the mastery adoption of the flipped classroom approach by both teachers. Students related that the videos helped them understand the content, which enabled them to pass the tests, leading to success in the subject and ultimately access to further study. The following comments are illustrative of the responses received:

I want to pursue maths in college and university and just the fact that it gives you a wider view of it and dives into the deeper understanding of topics such as calculus, number functions and stuff. At the start I didn't realise that it was actually video tutorials but once I did the first couple of lessons it got really easy and I'm going a lot better in maths this year than I did last year. [Jack, Grade 10]

I feel more motivated now definitely than I was last year; now I am striving to achieve; I'm always trying to get that A every test. [Mark, Grade 10]

It was also important that the tutorials were *relevant* – this was a strong theme in both the student and teacher interview data:

... he would have spent a lot of time making those videos - he sets out exactly what's going to be needed for the test he'll go through the text book, figure out which exercises he'll go from, say, questions 3 to 7 because he doesn't think 2 or 8 are going to be of any benefit. [Lee, Grade 10]

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. [Mr Burns]

Some students were motivated to access the videos because they wanted to be *prepared* for class, either in terms of understanding the content in order to achieve their goal, to remove uncertainty and anxiety about what would happen in class the next day, and/or to avoid “being embarrassed in front of your friends” [Lee, Grade 10]. The teachers also thought this was an important motivator, with Mr Hill commenting, for example, that:

... like I used to get annoyed um when you'd pass a kid in the playground and they'd say, Mr Hill what are we doing in maths today? I'm like, just wait for maths and I'll tell you when I get there ... but then I thought that kid's telling me they're engaged ... after I thought how would I feel if the Principal said OK, there's a PD staff meeting for an hour after school today, we'll see you there – straight away, I'd be like what's it about? What are we doing? And it would kind of stress me and I think well that's how the students feel. [Mr Hill]

Abeyseker and Dawson (2015) identified a sense of relatedness as being a motivating factor in terms of accessing the video tutorials. Bergman and Sams (2012) advocated the importance of the teacher preparing the videos and this was confirmed in an earlier study by Muir and Chick (2014). One of the advantages of having the teacher create the videos is that it also addresses the *relevance* motivator, and according to Bergman, “If you can be replaced by a YouTube clip, then you should be” (J. Bergman, personal communication, August 21, 2015). Both teachers felt that it was important that they created the videos, both in terms of relevance and enhancing the teacher/student relationship as the following comment from Mr Burns illustrates:

The one thing I really like about the flipped classroom is the close proximity I've come with my students ... 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.

[Mr Burns]

Although some students did not think that it was necessary to have the videos created by their teachers as long as they were relevant, it seemed that the relationship with the teacher actually acted as a motivator in its own right. Students appreciated the effort and time that went into creating the videos and virtually felt obligated to watch them as a result of this. Closely linked with this was students' appreciation of their teachers' efforts to make the videos *captivating* so as to engage attention. This included limiting the videos to ten minutes and including jokes and anecdotes.

Mr Hill brings a sort of enthusiasm with these videos and he just brings it across and like explains it very well. [Jack, Grade 10]

He [Mr Burns] kind of comes down to our level at times which is really good ... he will have a joke as well ... like with the factor of ten and he got the people from the horticulture thing to bring a goat so the G factor of ten is related to a goat then he got the goat to bleat ... [James, Grade 12]

In summary, the model proved useful for analysing the motivational factors influencing students' engagement with the flipped classroom. The findings are also consistent with those found in the literature that link motivation with self-directed learning. *Goal attainment, relevance* and *preparedness* relate to students' beliefs about their ability to perform a task and the importance and interest of the task (Pintrich & De Groot, 1990), and demonstrate a sense of competence (Abeyseker & Dawson, 2015); *relatedness* and *captivation* relates to students' emotional reactions to the task (Pintrich & DeGroot, 1990), and consistent with a sense of relatedness as identified by Abeyseker and Dawson (2015).

### *Affordances*

Once students are motivated to access the videos then they can take advantage of the approach's affordances. All students interviewed in this study reported that they did actually watch the videos and articulated a number of affordances with this approach compared to how they had experienced mathematics lessons in the past. The most dominant affordance identified by both teachers and students was the affordance of *optimisation of class time*:

You can go up to him and be like, I went wrong here, can you tell me how and do it with you 'cause it's really individual and I guess the fact that he's got all the tutorials and stuff already up there releases the burden of him teaching during the actual lessons and allows for him to just walk around the class and help people [Lee, Grade 10]

The kids are really into this system now – I have my whiteboard markers sitting next to me and kids will just generally walk up, and say do you mind if I just grab a marker, and they'll start working on the board and then when they're ready, like when they're at a point when they're stuck, they'll say Mr Hill, I've done this – where do I go from here? And I'll come up and show them and work them through it [Mr Hill]

[In the past] I'm thinking when are we ever going to get through this curriculum? I don't have that worry at all with these kids. [Mr Burns]

The students interviewed typically reported that accessing the videos at home helped their *capacity to focus*. In contrast to past experiences of listening to explanations in class, students reported that the *accessibility* of the videos enabled them to focus more on the content being delivered:

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. [Chris, Grade 12]

Other advantages of optimising class time include *differentiation* of learning and fostering a sense of *autonomy*:

He leaves it up to you; it lets you experience independent study; you could pretty much be away for all the in-class lessons but do it at home, then come for the test day and still be prepared. [James, Grade 10]

It doesn't really phase me having struggling students as well as more advanced students because I can support them [both] because I've got the face time. [Mr Hill]

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 3 or 4 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. [Mr Burns]

Students also experienced *autonomy* over their learning through the affordance of *self-pacing*. Self-pacing refers to both the practice of pausing and rewinding the video while viewing and working individually through the course content. For example, Fiona [Grade 10] stated that "if you can't do it in class, you've still got the videos to explain it and you can watch it numerous times", while Andrew commented that in the past the teacher disadvantaged them because "we couldn't go ahead". Operating within the mastery paradigm, students could autonomously access the content, and demonstrate mastery through passing 'the test', making the videos conducive to *assessment preparation*.

Preparation of the videos is initially resource intensive, but both teachers anticipated that the resources would be utilised in future years, with minor adjustments required to cater for any curriculum changes. Although both teachers did not routinely edit their videos, they both acknowledged that the medium of the delivery prompted them to think more carefully about the examples provided and how they *scaffolded understanding*. This was also noticed by some students who commented that the videos were often "to the point" and "helped me to understand" [Fiona, Grade 10]. Attending class having some understanding of the concepts to be covered also helped to *prime* students, which is an element of self-directed learning and related to the motivational factor of *preparedness*. *Priming* as an affordance was not a major theme for this study as students were working individually through the content. In other contexts where students work through the curriculum at the same pace, *priming* would likely be more of a perceived benefit.

## Conclusions

Although acknowledging the limitations associated with two small cases involving relatively motivated students, the results show that the flipped classroom may be an appropriate approach to assist with the challenges of teaching senior secondary mathematics. In contrast with traditional teaching practices experienced in the past, students found the video tutorials prepared by their teachers to be relevant, engaged their attention, provided for greater autonomy over their learning and enabled them to attain their goal of mastery over their learning. The framework proved useful for interpreting both teachers' and students' perceptions in terms of identifying what motivates engagement with the approach and the specific affordances it offers. The study has practical implications for teachers who find individual instruction a challenge and who are looking for ways to optimise class time in order to cover the prescribed curriculum and prepare students for externally imposed assessment tasks.

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