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Learning Engineering through the Flipped Classroom Approach- Students' Perspectives

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Abstract

A flipped classroom approach consists of two distinct parts: direct on-line instruction in the students' own time and at their own pace, and interactive group learning and problem-solving activities in scheduled classes. This approach has the potential to suit theoretical and practice-based courses such as technology education. This article outlines a study on students' views of using the flipped classroom approach to learning from the perspective of first and second year engineering students undertaking a module of learning in Dynamics. Engineering, like many technology related courses is both theoretical and practical in nature. The study investigates students' views of the use of the flipped classroom approach using focus-group and individual interviews after they had experienced it. The flipped classroom approach facilitated students' exposure to theoretical ideas in their own time through online lectures, thus maximising time for problem solving activity with their face-to-face lecturer support. This research suggests several key factors within two broad categories that students felt influenced their learning. These categories were identified as Perspectives of Lecturer Behaviour and Perspectives on Student Behaviour. The article concludes with a number of recommendations aimed at improving the teaching and learning experiences for students in the flipped classroom and makes links to the potential applications for other design and technology education disciplines.

Key words

engineering education, flipped classroom, collaboration, student perspectives, teaching and learning

Introduction

There is significant pressure on tertiary educators to improve the efficiency and effectiveness of their teaching and to engage with innovative teaching methods using digital technologies, however understandably many have no expertise or interest in educational pedagogies (Serdyukov, 2015). This article outlines a study undertaken by academics from three fields of learning (E-learning, teacher education and engineering) and investigates students' views on aspects of the flipped classroom approach. The

research builds on recent literature in the field of innovative teaching approaches and adds to the body of knowledge around student voice about teaching approach. The article concludes by recommending a number of behaviours for lecturers and students to enhance learning during this pedagogical approach. The study, qualitative in nature was part of a wider mixed methods study on using a flipped classroom approach to learning in a university engineering programme.

The flipped classroom approach, although first introduced as early as 1982 (Baker, 2000) has become popular in recent times in many educational institutions due to advances in educational technologies, pressure to improve student performance, a willingness to challenge established teaching methods, and fiscal pressures within universities (Carpenter, Blythe, Sweet, Winter & Bunnell, 2015; Serdyukov, 2015). The flipped classroom approach to learning has the potential to provide educators with opportunities of maximizing and increasing the quality of face-to-face instruction as students are asked to come to class having already engaged with course materials. However, it is important to consider students' views of the approach to ensure the best outcomes for students and their learning.

This study investigated engineering students' perspectives of the flipped classroom approach used to teach a summer school paper in two consecutive years. The content included foundational engineering dynamics and was taught to first year students as a part of a four-year university degree programme in New Zealand. It was the lecturer's first encounter with the flipped classroom approach and the aim of the study was to ascertain the success of the approach from the students' point-of-view in terms of their experiences about the approach used. The article includes a range of participants' recommendations to improve the flipped classroom experience.

Motivation for the Study

There is an increasing body of literature reporting a range of success with the flipped classroom approach (Blair, Maharaj, & Primus, 2016; Gannod, Burge, & Helmick, 2008; Lavelle, Stimpson, & Brill, 2013; Love, Hodge, Grandgenett, & Swift, 2014). Recent changes and pressures in tertiary teaching sector have led to an increased uptake of alternative methods of teaching and learning (Blair et al., 2016; Comber & Brady-Van den Bos, 2018; Serdyukov, 2015). Today's students are demanding more from their educational institutions. In the information age, they are connected and aware of what others are getting. They can compare and contrast approaches and therefore request access to information in a variety of mediums. Thus, institutions must support and improve learning experiences for their students to remain competitive. There is also increased pressure from qualification authorities and governments for universities and other tertiary institutions to perform more effectively and efficiently (Bishop & Verleger, 2013; O'Flaherty & Phillips, 2015).

To vary teaching and improve experiences for engineering students, a flipped classroom approach was trialed during the condensed summer school programme two years in

succession. This study aimed to determine the students' perceptions and experiences of the approach with the aim to make further improvements, and recommendations for similar problem solving and practically based courses.

Literature Review

Flipped Classroom Defined

A flipped classroom approach consists of two distinct parts: direct on-line instruction at the students' own time and pace, and interactive group learning activities in scheduled classes (Bishop & Verleger, 2013; Comber & Brady-Van den Bos, 2018). Course content can be presented in the form of readings, videos, graphical presentations or quizzes (Blair et al., 2016; Hanson, 2016; Lavelle et al., 2013). These online 'lectures' are followed up with lecturer or teacher run workshops within which students engage with the recently delivered course materials, thus putting theory into practice. Such sessions typically include elements of interactive, collaborative and applicative engagement in problem solving (Bishop & Verleger, 2013; Hanson, 2016; Lavelle et al., 2013).

Rationale for and Characteristics of Flipped Classroom in Tertiary Education

Students in the 21st Century require a wide range of 'soft' skills and knowledge. These skills best occur in authentic learning situations and include greater collaboration, communication, problem solving and critical thinking (Snape, 2017). Utilisation of the flipped classroom approach has increased in recent years in response to this change in learning practices of students who also increasingly tend to access information via information and communication technologies (ICT) (Hanson, 2016; Serdyukov, 2015). Blair and colleagues (2016) and Serdyukov (2015) suggest that recent ICT advances have assisted the facilitation of the shift in tertiary teaching from the traditional teacher-centred approach to a learner centred approach.

The shift to learner-centred pedagogy aligns with sociocultural learning theory based on the works of Vygotsky, Piaget and Dewey (Serdyukov, 2015) and socio-constructivist theory (Snape, 2017). Many of Vygotsky's (1978) ideas, particularly the Zone of Proximal Development, are directly relevant to student learning. Sociocultural approaches to education and learning are different from approaches that are more traditional. In sociocultural theory, focus is on the roles teachers or more capable peers play in learning with an emphasis on peer group interactions and collaborative learning (Daniels, 1996; Richardson, 1998). Snape (2017) suggests that socio-constructivist learning is self-regulated, situated in social, contextual and cultural environments, and collaborative in nature. Clarke (2014) states that cognitive ability is able to be grown, as opposed to being fixed as was understood in earlier times. Allowing students, the flexibility to learn in differing ways using a range of strategies increases opportunities for a wider range of students to achieve.

Online learning, can be individualised, however it is more likely to be successful when taking place within learning communities (Serdyukov, 2015). The concept of guided participation in activities is essential to students' apprenticeship into thinking within new contexts (Bishop & Verleger, 2013; Rogoff, 1990). These ideas are particularly relevant to the flipped classroom approach as learning occurs both independently and through collaborative activity (Lavelle et al., 2013). Course content is engaged with independently, while subsequent scheduled classes offer opportunities for collaboration, higher-level thinking, and exposure to varied ideas and understandings from peers, as well as engagement with authentic practical activities that apply and extend on-line lecture materials. Choi (2013) states that successful engineering education must develop real-world skills. The flipped classroom works well in lab-based classes (Lavelle et al., 2013) due to the practical and interactive nature of laboratory sessions. Hence, the increased direct student-teacher engagement can facilitate better mentoring of practical skills. This mentoring can occur on a needs basis as lecturers' time spent on lecturing occurs before scheduled class times (Lavelle et al., 2013).

Mayer (2002) suggests that the flipped approach to learning facilitates long term retention and application of course material, as opposed to simple transfer of knowledge and facts, as is the case in traditional classrooms. Lavelle et al. (2013), Johnson and Renner (2012) and Blair et al. (2016) identify a number of other advantages in using the flipped classroom approach. These include developing critical and higher-level thinking, more opportunities for collaborative work, and increased face-to-face interaction with the lecturer, student schedule flexibility and ability to review and or pause lecture materials when needed. Learning is easily modified for a diverse range of learners as the video and other pre-lecture materials can be planned to ensure the needs of all students are met, including those with disabilities. Post viewing reflective activities can also be developed for formative assessment purposes to enable the lecturer to ensure following workshop activities meet the specific learning needs of the students. Choi (2013) states that an ideal educational environment provides students with specific and immediate feedback. The flipped classroom approach enables this if on-line lecture materials are relevant, provision is made by the lecture for reflective feedback from students, and then workshop activities are carefully designed to meet emerging student needs with opportunities for immediate feedback for students as they work through them.

Sociocultural conflict theory is also relevant to the flipped classroom approach to learning. It suggests that discrepancy or conflict best sparks cognitive development. Socio-cognitive conflict theory identifies conflict as an essential ingredient to bring about cognitive change. Doise and Mugny (1984) have demonstrated that students working in pairs solve problems at a more advanced level than those working by themselves regardless of the ability of the partner. They found that when students were challenged with an alternative opinion to their own, student performance improved, regardless of the validity of the opposing viewpoint. The conflict can only be resolved if cognitive restructuring takes place, and

therefore mental change occurs because of social interaction. The social, collaborative and problem-solving nature of the practical workshop activities used in the second part of the flipped classroom approach are a perfect opportunity for students to learn through debate and discussion while engaging in relevant problem solving.

Baker (2000) identified key characteristics of successful flipped classroom implementations. These include a change in role for the teacher to a 'facilitator' rather than a 'director' of learning, and a reduction in lecturing. Increased use of active learning with a focus on understanding and application and the provision of student control are also characteristics as well as a greater sense of student responsibility over learning. Students have greater opportunity to engage with their lecturer one-on-one, and the opportunity to learn collaboratively with peers. Gannod et al. (2008) reiterate the need for facilitated collaborative learning. They note that groups of students must achieve consensus to solve particular tasks. This means considerable higher-level thinking, discussion, debating and repositioning of ideas may be necessary. Proper facilitation of the workshops shows students that their lecturer is interested in them and their learning, but failure to do so may lead to disengagement (Choi, 2013). Popular at first with subjects from the humanities Carpenter et al. (2015) suggest that recent technological advances have made the approach more popular with Science, Technology, Engineering and Mathematics (STEM) based courses.

The flipped classroom approach holds a number of challenges and disadvantages. Mason, Shuman, and Cook (2013) identified three major difficulties with the flipped classroom approach 1) time computation, 2) student discomfort with taking responsibility for their own learning, 3) discrepancies in the literature about the flipped approach in some courses. Johnson and Renner (2012) suggest that a strong work ethic is needed for success in the flipped classroom environment both from the teachers' and students' points-of-view. Furthermore, not all students will be inclined to view the materials prior to their workshop classes. Also the development of the materials is labour intensive (Lavelle et al., 2013) for lecturers and video materials may not very easily corrected or modified. Mason et al. (2013) state that their biggest concern is flipped classroom pedagogy. The approach assumes that students have on-line access, this can prove difficult for students in rural areas and the assumption that students have the pre-requisite skills and web-based technology necessary for successful implementation. This could mean students become disengaged and leave their courses (Carpenter et al., 2015). Many university campus classrooms have been designed for a traditional lecture approach to teaching. This setting makes mobility and collaborative work desirable in the flipped approach, a challenge (Carpenter et al., 2015). Therefore, before undertaking a significant shift to a broad ranging flipped approach it is critical for universities to explore the feasibility of this approach.

Students' Perceptions of the Flipped Approach to Learning

Students' perceptions of the flipped classroom are particularly varied (Blair et al., 2016; Hanson, 2016; Johnson & Renner, 2012; Love et al., 2014; Nguyen, Yu, Japutra, & Chen C-H. S., 2015). Blair and Colleagues (2016) report that engineering students were keen to continue with the flipped approach after engaging with it. Students' perceptions of the flipped classroom approach was influenced by the quality of the course content materials used (Blair et al., 2016). Hanson (2016) reported several advantages, these included increased understanding through dialogue in the face-to-face component, wider and deeper thinking, the ability to pause and replay the online lecture material and the flexibility of time to avoid conflicting commitments and students also acknowledged a reduced sense of isolation and disengagement. Students in several studies acknowledged that the flipped approach required different teaching and learning approaches to ensure individual grades did not suffer and recognised the approach required self-discipline and a change in study habits. They also recognised that the flipped approach was more efficient than more traditional approaches (Blair et al., 2016; Hanson, 2016; Nguyen et al., 2015; O'Flaherty & Phillips, 2015).

Nguyen et al. (2015) reported that students appreciated being able to talk to their peers while viewing the online lecture materials. They felt that dialogue and engagement with peers was beneficial and an important aspect of good teaching practice. Students also recognised engagement in the recorded online material as critical (Blair et al., 2016; Nguyen et al., 2015; Pierce & Fox, 2012). Students in several studies valued the reviewability of the materials and the ability to engage with course materials before the workshop (Blair et al., 2016; Love et al., 2014; Pierce & Fox, 2012). Hanson (2016) reported that not all students were positive about the change in approach. One key aspect of Hanson's study was that students felt that the process and potential benefits of the flipped classroom approach needed to be explained to them clearly from the beginning. This concurs with a study by O'Flaherty & Philips (2015), where students felt that they needed to be told that attendance at both components of the flipped approach (independent lecture and workshop) were necessary for success in the course. Nguyen (2015) and Zhu, Y., Wing, A. & Yates, G. (2016) suggest that students need to understand the value of self-preparation and self-control before engaging in flipped education.

Methodology

This article reports on an interpretive qualitative study, which was part of a greater mixed methods study to investigate students' perceptions of the flipped classroom. The findings of the study are reported as a mixed cohort of students who participated in the flipped classroom over two subsequent summer schools in during the 2014-2016 period. The theoretical paradigm of *interpretivism* is the study of meaningful social action and is predominantly concerned with achieving understanding through feelings and world views (Neuman, 2000). The central aim of the interpretive paradigm is to understand the

subjective world of human experience while maintaining the integrity of the subject. It also aims to understand how people construct meaning in a natural setting (Neuman, 2000; Taylor & Bogdan, 1998). This approach enables researchers to examine students' perspectives on how they interacted with their lecturer, peers, technologies and other culturally situated tools to construct knowledge and understanding in dynamics engineering.

The study occurred over a two-year period and investigated the views of 18 students who undertook the flipped classroom approach for one summer semester paper. The sample size is small so results should be viewed accordingly, however student voice enables deeper understandings to emerge that may not be evident through quantitative data. All course members were emailed and asked if they would like to participate in the study. In the initial email and again on the participant consent forms anonymity for all students was guaranteed. All but two of those who agreed participated in one of several semi-structured focus group interviews, however scheduling limitations required two individual interviews. Either one or two of the authors undertook the interviews. Interviews were transcribed and subsequently coded and analysed to identify themes and several key factors that influenced students' experiences and perspectives of the flipped classroom approach.

Aspects of this research were educationally sensitive (Cohen & Manion, 1994) as one of the authors was the course lecturer and in a position of authority over the students. Due to this ethical consideration, this researcher did not undertake any of the interviews, and only received anonymised interview transcripts. Semi-structured interviews are designed to explore how, people behave, what they do and why (Taylor & Bogdan, 1998). One of the advantages of the focus group is that they are likely to yield insight not otherwise accessible in other forms of interview as the participants are prompted by other's contributions (Cohen, Manion, & Morrison, 2001). A noted disadvantage of focus group interviews is that they must be interpreted in terms of the group dynamics as this could well impact on the contribution of some of the participants (Taylor & Bogdan, 1998).

Findings

The findings in this study support the findings of a number of other studies (Comber & Brady-Van den Bos, 2018; Pierce & Fox, 2012). In general, most students responded positively to the flipped classroom experience, however, one student in this study was notably negative. This study further analyses aspects of the practice that impacted students' views. The data suggests that student impressions of the influences on their learning in the flipped classroom can be divided into two broad categories: perspectives of lecturer practice, and perspectives of student practice. Each exhibited a number of key factors summarized in Table 1. Some key factors, such as student responsibility for time management, or working collaboratively were regarded both positively and negatively across the cohort. The description of each factor is supplemented by a range of recommendations that were derived either directly or indirectly from student comments.

Table 1: Broad Categories and Key Factors of Students' Perceptions of the Flipped Classroom Approach in Engineering Education.

Perspectives of Lecturer Practice	Perspectives of Student Practice
• Course Materials • The Process • Lecturer Approach • Preparation of Students	• Reviewability • Independence • Time Management • Working Collaboratively

Students' Perspectives of Lecture Practice with Associated Recommendations

Course Materials

A number of students commented that course materials were easy to use in their own time and at their own pace within the designated online learning environment (based on the Moodle platform); however nearly all of the students experienced frustration because of a number of errors in the video material. Students recognized that mistakes would be time consuming to fix, some even offered a solution:

> *Have you guys watched The Khan Academy, so… [the lecturer] was complaining that if he has an error in his recordings then he has to start from scratch. He was having editing issues, but what Sal [in the Khan videos] does he just puts a little text box at the bottom and says, hey look, this is wrong and this is what I meant to say. It would have reduced the time and effort that we spend quite dramatically (Student D).*

Students appreciated the emphasis on collaborative problem solving during workshops and the direct connection to the online material each week. A number of students would have preferred earlier access to lecture material in order to prepare adequately for workshops. "Maybe write a list of questions out and then you know what you will ask at the next tutorial. Just keeping up-to-date" (Student N). Others mentioned that they would like a variety of materials used in the on-line environment. One student suggested having an additional online forum as a part of the course. Some students experienced frustration with the on-line materials because of their length and the time taken to watch it thoroughly. "For me it was at least three hours in the evening after I came home from work…you finish that and you are exhausted" (Student A).

Student comments with regards to course materials give rise to a range of recommendations; materials should be presented to students in a varied and balanced delivery, deploying a range of teaching and learning strategies to ensure that students remain engaged in the course. Such strategies could include: lecturer developed videos, use of existing materials available on the internet (such as Khan Academy), on-line forum,

post video quizzes, authentic collaborative problem solving and activities using innovative ICT tools as they emerge such as Padlet or Google Sites.

In addition, students need to have confidence that the material with which they are engaging is of a high standard, succinct and engaging. Some sort of professional assistance for staff as they develop video and other in line materials would be valuable. Furthermore, based on student comments on how and when they engaged with the materials, making workshop and video lecture material available to the students well in advance will enable them to better manage their time and self-paced learning. Along with this a very clear schedule of the face-to-face workshops with a detailed outline of content is recommended so that students are adequately prepared for each workshop.

The Process

Most students were positive about the process with several indicating that they experienced increased engagement because of it.

> When you're taking notes in real time lectures you focus more on taking notes and you don't have time to digest the information and they find it quite useful; that [in the flipped classroom] they could pause and think about what they just wrote, and the content sunk in better (Student O).

Over half of the students mentioned that they like the frequency of the tutorials, which were held at least twice weekly during the course. A number of students mentioned the course forced their engagement, while most thought this was a positive aspect; "compared to my first-year grade I was normally [understanding course content] on a higher level so yeah I was more engaged, I was willing to work harder" (Student F). Another student suggested that although the course took more time than the traditional approach she knew the material better and therefore needed less study for the end of course examination.

Three students specifically mentioned the approach led to improved achievement, "I'd say just that the teacher and the way he taught was very effective and reflected in my results" (Student L). Nearly all students were very positive about the collaborative nature of the workshops, the opportunity to interact with the lecturer on a one-to-one basis and liked the small class sizes and the resulting group dynamics. "We were sitting in groups and the girls in my group really helped me out" (Student F), "you kind of need someone who learns with you" (Student F). It is worth noting that the lecturer frequently collected feedback from students (formally and informally), about their views on the effectiveness of the flipped approach and their enjoyment of the process. This was an important part of the process and therefore a recommendation stemming from the findings, as long as subsequent actions rectify students' frustrations.

Lecturer Approach

Students in the study were very positive about their lecturer approach during the course and indicated that they experienced increased engagement during the flipped classroom. Students mentioned that the lecturer's positive attitude, approachability and willingness to provide thorough explanations as important aspects of his approach that assisted them in further developing their understanding during the scheduled workshops. "[It was] easier to get that one-on-one time, easier to get the help you needed" (Student M). "I'd say just the teacher and the way he taught it was very effective, and that reflected in my results" (Student L). Students mentioned that the one-on-one time they had with the lecturer during the workshop sessions was an essential element of the flipped approach that helped them remain engaged and enjoy the process "the classroom was smaller, so it was like a closer connection between the teacher and you" (Student F).

Another aspect of the lecturer approach that the students experienced positively was his dedication and time commitment preparing the course materials. Two students specifically mentioned appreciation of the lecturer's time investment into the process. Some students suggested that the lecturer, as well as develop his own material also access and make use of readily available on-line material. *The Khan Academy* was mentioned several times as an alternative freely available resource that lecturers do not always use: "Lecturers tend not to use that resource [internet], they don't give you links, they don't engage with the thing" (Student A).

Based on student feedback with regards to the lecturer approach, a positive lecturer approach with the belief that all students have the potential to learn is essential. If all students have the potential to learn then it stands to reason that lecturer approach and attitude are significant contributing factors in students' achievement. A growth mind-set to intelligence (Clarke, 2008) will assist lecturers in understanding that their approach to their students and the strategies and material they are teaching has a huge impact on students' achievement.

Preparation of Students

Several students commented that they felt that they should have been better prepared for the process as it involved an entirely different way of working. One of the students explained that this could have been better achieved with the support and facilitation of the lecturer: "You need to purchase that approach with a different approach as well as think about it. You need to explain that material to a person who doesn't really understand. You need to guide them through several courses" (Student A).

A minority of students surveyed preferred the traditional approach. Several students mentioned that after having experienced the flipped approach in this course they would be happy to undertake more courses that use the flipped approach, however many of them

identified several limitations in using a flipped approach in more than a few courses at a time. “Running four papers doing a flipped learning would be an immense undertaking, just the time commitment” (Student D).

It is clear from these findings that then undertaking learning through a flipped classroom approach students need to be well prepared for the process. The lecturer has an important role in clearly explaining the process, its rationale, underpinning philosophy and advantages to all participants. Students’ requirements and lecturer’s expectations should be very clearly outlined from the outset. It should not be assumed that students know how to manage their time for effective self-paced learning. Specific time management strategies can be taught and scaffolded timetables provided for those new to the approach.

In addition, gradually enabling students to transition from learning in a traditional setting to learning a flipped environment might be beneficial. Ensuring students have a balanced programme with a variety of approaches may provide them with the required time to get used to the new approach, while maintaining a positive attitude towards new ways of learning.

Students’ Perspectives of Student Practice with Associated Recommendations

Reviewability

Generally, students were positive about the approach “I think I probably went a bit better for me doing the flipped instead of the traditional approach. Personally for me I like the dynamics need more tutorial/ lecture time, like engaging and asking questions about things I got stuck on. So that really helped me (Student N)”. One major advantage indicated by the students was the ability to view and re-engage with course content until satisfactory comprehension was reached, “I really enjoyed it coz I was able to pause it if I didn’t know something, pause it, google it, pause it, do something else, come back to it and it didn’t feel like you had to stay there the whole time” (Student I).

Independence

Most students appreciated that the lectures were closely followed by workshops and indicated that the approach meant that they were able to work more independently than in the traditional setting and thus gained a sense of empowerment:

> The flipped classroom is very self-directed learning. You have to sit down at home, you have to watch the lecture, you have to take notes by yourself, there is no one telling you that you have to be there in class, you can do whatever you want, you don’t have to go to the tutorial, you go there if you want help, if you want to push yourself and you want to learn more…but I think I really benefitted from it in the end. I really enjoyed the style and gained a lot more

> from, you get the materials beforehand because I think it gave me time to process it, digest it, to understand what I was looking at before I actually went in a did it (Student M).

A majority of the students liked the self-paced nature of the course, however a few felt that this disadvantaged them. A number of students noted the time commitment needed for viewing then reviewing lecture material.; "So it forces me to invest more time than I want to, than I can" (Student A). Two students noted that they believed the approach failed to prepare them for the schedules expected as professionals not always have the flexibility to prepare at their own pace before they solve real-life problems, "For quite a lot of jobs that you're going to get coming out of a degree like this, you don't wake up whenever you want and go to work" (student J). Nearly all students recognised the need for self-responsibility and discipline when engaging in a flipped classroom. "It takes a lot of self-control" (Student C). While some students thought this was advantageous, others recognised their own lack of self-disciple or maturity to cope with the approach meant that they were not as successful as they had hoped. A few students indicated that the flipped classroom approach might be more suitable for more self-disciplined students. "I wouldn't have been able to do it when I was 18. There wouldn't have been a chance" (Student P).

These findings further indicate the importance of students' preparedness for the flipped classroom. Students in this study recognised the considerable difference to other approaches, and the need to adapt. In addition to the recommendation described earlier with regards to the lecturer's role in preparing students for flipped learning, students themselves need to commit to taking on board strategies to self-direct and take ownership of their learning.

Time Management

Students recognised the importance of time management in the success in the flipped approach. Many students found that the on-line lectures took too long to watch and that the flipped approach generally took considerably more time than the traditional approach. "At some point I was struggling to keep up with watching the videos...also a bad thing because you spent a lot more time going over it", (Student L). A number of students mentioned the need to engage in the prescribed course material at the appropriate times. "The moment you missed one and you go to the tutorial and have no idea what's going on and then you kind of not waste that tutorial but you can't fully engage in it so you have to re-watch it that night to catch-up" (Student O). Another felt that the increased investment in time was not reflected in improved grades. Some students indicated that they could have been better prepared for the flipped classroom approach, as it was difficult for them to learn in a non-traditional way.

These findings suggest that to succeed in the flipped classroom students must develop time management strategies and be self-disciplined to ensure lectures are viewed and materials engaged with in a timely manner. They also need to consider their preferred

learning style, strategies that best suit their needs and where and how they can get assistance if required.

Working Collaboratively

The fourth factor in the student behaviour category was the collaborative nature of learning especially in the workshops. The majority of participants liked the collaborative nature of the workshops and enjoyed the resulting group dynamics. Most appreciated the small size of the classes and increased lecturer interaction compared to traditional classes.

> I definitely feel that working with a partner or small group really helped. As soon as I hit a road block or something that I didn't understand, I could bounce ideas off [student name] and he could do the same for me (Student D).

Two students indicated that they felt a responsibility to the group and made sure they were prepared to contribute at workshops. One student mentioned watching the on-line material with a classmate. They paused the video to clarify and discuss conceptual barriers,

> I was doing it with a very good friend of mine. We spent a lot of time we'd watch them together and we'd hit a problem and we'd both work through what [the lecturer] was trying to get towards, and the next day we'd be very confident in what we'd got (Student D).

Another student, while watching the material individually discussed and debated lecture material with a flat-mate also in the course. Socio-cultural conflict theory states that coming up against ideas differing to one's own enhance cognitive development when learners are open to change (Doise & Mugny, 1984). This was clear4ly demonstrated by a number of the students in this study.

Discussion and Recommendations

This study supports other studies presented in the literature on student perspectives of the flipped classroom in relation to students' behavioural factors (Hanson, 2016; Nguyen et al., 2015) and lecturer behavioural factors (Blair et al., 2016). This study has also identified a number of recommendations to improve the pedagogical approaches to the flipped learning with the aim of assisting tertiary academics from fields other than education in preparing their course materials, their students and themselves for the flipped classroom approach to learning.

One rationale for adoption of flipped classrooms in tertiary settings is the need to move to student-centred, problem-based learning, thus aligning with Vygotsky's (1978) sociocultural theory. Comber and Brady-Van den Bos (2018) found that student-lecturer relationships impacted on students' views of the flipped classroom approach. The positive approach of the lecturer in this study and his availability in workshops impacted on the

students; views of the approach. When using the approach students gained immediate feedback in the workshops.

Quality materials facilitate a deep understanding given their problem solving and collaborative approach (Choi, 2013; Maykut & Morehouse, 1994; Serdyukov, 2015). Like those in Nguyen et al's (2015) study students in this study indicated that although the flipped approach took more of their time, the reviewability of the materials and the collaborative nature of the workshops enabled a deeper understanding course material, however it supports Nguyen's findings related to quality of materials and these participants became were frustrated with a number of errors in the on-line materials.

Working collaboratively often involves coming up with differing views and supports sociocultural conflict theory (Doise & Mugny, 1984) that all learners' cognitive development, regardless of proficiency is benefitted by understanding alternative views and working with peers. Debate, argument and or disagreement assists students' cognitive development, if participants are open to change and new ideas (Doise & Mugny, 1984; Fox-Turnbull, 2016). Intercognitive conversation also plays an important role in the collaborative learning process. This type of conversation is one within which all participants gain new understandings through engagement in reflective dialogue. When participants are learning in, and about, a common context and engaged in constructive dialogue they assist each other while advancing their own knowledge (Fox-Turnbull, 2008). A number of students in this study mentioned the value of collaborative work when engaging in the on-line materials and with the workshop material. This aligns Mayer's (2002) study that suggested increased value of face-to-face interaction both with the lecturer and peers, and supports apprenticeship of thinking theory (Bishop & Verleger, 2013; Doise & Mugny, 1984; Lavelle et al., 2013). It also concurs with Serdyukov's (2015) ideas about the importance of collaboration and communication in the learning process.

Another advantage of the flipped approach, for students in this study and for the participants of a number of other studies (Blair et al., 2016; Johnson & Renner, 2012; Lavelle et al., 2013) was that they could adjust the course content delivery rate to their preference and review it at their own discretion. These findings also support the theory of the success and importance of student-centred learning (Vygotsky, 1978). Some students in this study, however felt that the flipped approach took more of their time and indicated that undertaking too many flipped approach courses at one time could be problematic. Students in the study recommended only having one or two courses using the flipped per semester. Thus we suggest that when considering whether to implement the flipped approach, university faculties and staff consider the broader view of the total student experience. Students should be offered a balanced varied programme, using a range of delivery methods designed to best suit their needs.

Mason et al. (2013) cited time management as an issue with the flipped classroom approach. This was partially supported by the findings in this study. Students

acknowledged that the course was time consuming overall, however they also indicated that this was not necessarily a negative aspect as they made efficient use of the time and hence were able to decrease the burden of exam study. Hanson (2016) suggests that students need to be well prepared for the flipped classroom approach to learning. The findings of this study supported this as students found the approach more time consuming and felt that they needed to demonstrate strong time-management skills to succeed with the approach. Students need to have an understanding of the pedagogical principles underpinning the approach and to have specific strategies modelled to them (Admiraal et al., 2017). This study also determines that students need to understand the philosophy and pedagogy underpinning the flipped approach. Issues that emerged in this study such as lack of time management, self-discipline and inability to work collaboratively also emerged in other studies (Johnson & Renner, 2012; Lavelle et al., 2013; Mayer, 2002). Specific skills to assist students' preparedness need to be presented and modelled to students by teaching specific strategies for engaging with the approach and to increase students' receptiveness to new educational strategies and decision making to increase engagement with peers and lecturers in the flipped classroom as this will impact student learning considerably (Admiraal et al., 2017).

The quality of the lecturer developed materials in this study had a considerable impact of students' perspectives of the flipped approach and supports similar findings by Blair et al. (2016). The video materials developed had several mathematical and formulaic errors that were very time consuming to correct. While students were understanding of the difficulty in fixing the errors in the videos some indicated that the errors shook their self-confidence and increased the time spent viewing on-line materials, however others saw the mistakes as an advantage as they were forced to think very deeply and critically about the materials and the differences between their ideas and that presented on the video. Thus, coming up against alternative views to their own (Doise & Mugny, 1984).
To assist lecturers in the preparation of eLearning materials for the flipped classroom approach the authors make a number of recommendations. These recommendations, summarised in Table 2. are based on those presented in the findings section of this paper further informed by pedagogical knowledge.

Table 2 Key Recommendations for using the Flipped Classroom Approach in Tertiary Teaching

Recommendations for Lecturers	**Recommendations for Students**
• Variety of Materials • High Quality of Materials • Workshop Materials Signalled in Advance • Positive Lecturer Approach	• Thorough Student Preparedness • Positive Student Attitude • Organized Time Management Skills • Understanding Communication and Collaboration Skills' Role in Learning

• Specific Preparation of Students to the Approach • Understanding Communication and Collaboration Skills' Role in Learning	

As stated previously the students in this study frequently mentioned the value of the collaborative nature of the workshops, although they did not directly recommend specific collaborative strategies as a part of the flipped classroom approach. Collaboration and communication are vital components in the teaching and learning process (Clarke, 2014; Fox-Turnbull, 2016; Serdyukov, 2015). This justifies the additional final bullet point in each column in Table 2. Lecturers must believe in and model strong communication and collaborative skills to assist their students in developing their own understanding of the place and role communication and collaboration plays in learning.

Conclusion

This study aimed to investigate students' perceptions of a flipped classroom approach to learning dynamics in a Bachelor of Engineering programme in a New Zealand university. It found that students were mostly positive about the approach, which in part had to do with the process of the flipped classroom, but also to do with the approach of the lecturer. Students' perceptions of the flipped approach were broken down into two main categories, the first of which is Perceptions of Lecturer Practice which included the approach and delivery style of the lecturer, the development and quality of the course materials, the implementation of the process and the extent which the students were prepared by the lecturer for the changed approach. The second category Perceptions of Students' Practice included their preparedness for the self-directed approach to learning, the ability or willingness to engage with course materials and peers and their ability to manage their time throughout the course.

Having established best practice within the flipped classroom we can now turn to it application for design and technology related subjects in secondary and tertiary situations. Because of the practical nature of technology related subjects, the need for specialist facilities (often in short supply) and specialist teachers the flipped classroom offers an opportunity to maximize the use of specialist facilities and people. Students engage with theoretical ideas through the recorded classes which they then apply in 'class' time with specialist facilities and teachers.

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References

Admiraal, W., van Vugt, F., Kranenburg, F., Koster, B., Smit, B., Weijers, S., & Lockhorst, D. (2017). Preparing pre-service teachers to integrate technology into K–12 instruction: evaluation of a technology-infused approach. *Technology, Pedagogy and Education, 26*(1), 105-120. doi: https://doi.org/10.1080/1475939X.2016.1163283

Baker, J. W. (2000). *The "classroom flip": Using web course management tools to become a guide by the side*. Paper presented at the 11th International Conference on College Teaching and Learning, Jacksonville, FL.

Bishop, J. L., & Verleger, M. A. (2013). *The flipped classroom: a journey of research*. Paper presented at the 120th ASEE Annual Conference & Exposition.

Blair, E., Maharaj, C., & Primus, S. (2016). Performance and perception in the flipped classroom. *Education and Information Technologies, 21*(6), 1465–1482. doi:10.1007/s10639-015-9393-5

Carpenter, R. G., Blythe, H., Sweet, C., Winter, R., & Bunnell, A. (2015). A challenge for the flipped classroom: Addressing spatial divides. In A. G. Scheg (Ed.), *Implementation and critical assessment of the flipped classroom experience* pp. 353. Hershey PA, USA: IGI Global.

Choi, E. M. (2013). Applying inverted classroom to software engineering education. *International Journal of e-Education, e-Business, e-Management and e-Learning, 3*(2), 121-125.

Clarke, S. (2008). *Active learning through formative assessment*. London: Hodder Education.

Clarke, S. (2014). *Outstanding formative assessment: culture and practice*. London: Hodder Education.

Cohen, L., & Manion, L. (1994). *Research methods in education*. London: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2001). *Research methods in education* (fifth ed.). London: Rutledge Falmer.

Comber, D. P. M., & Brady-Van den Bos, M. (2018). Too much, too soon? A critical investigation into factors that make Flipped Classrooms effective. *Higher Education Research & Development, 37*(4), 683-697. doi:10.1080/07294360.2018.1455642

Daniels, H. (1996). *An introduction to Vygotsky*. London: Routledge.

Doise, W., & Mugny, G. (1984). *The Social Development of Intellect*. Oxford Pergamon Press.

Fox-Turnbull, W. (2008). *The place of conversation in learning technology*. Paper presented at the PATT- 20 Pupil's Attitudes Towards Technology International Design & Technology Conference Tel Aviv.

Fox-Turnbull, W. (2016). The nature of primary students' conversation in technology education. *International Journal of Technology and Design Education, 26*(1), 21-41.

Gannod, G. C., Burge, J. E., & Helmick, M. T. (2008, May 10 - 18). *Using the inverted classroom to teach software engineering.* Paper presented at the ICSE '08, Leipzig, Germany.

Hanson, J. (2016). Surveying the experiences and perceptions of undergraduate nursing students of a flipped classroom approach to increase understanding of drug science and its application to clinical practice. *Nurse Education in Practice, 16*, 79-85.

Johnson, L. W., & Renner, J. D. (2012). *Effect of the flipped classroom model on a secondary computer applications course: student and teacher perceptions, questions and student achievement.* (EdD. Dissertation), University of Louisville, Louisville, Kentucky. Retrieved from https://theflippedclassroom.files.wordpress.com/2012/04/johnson-renner-2012.pdf

Lavelle, J. P., Stimpson, M. T., & Brill, E. D. (2013). *Flipped Out Engineering Economy: Converting a Traditional Class to an Inverted Model.* Paper presented at the Industrial and Systems Engineering Research Conference

Love, B., Hodge, A., Grandgenett, N., & Swift, A. W. (2014). Student learning and perceptions in a flipped linear algebra course. *International Journal of Mathematical Education in Science and Technology, 45*(3), 317-324. doi:10.1080/0020739X.2013.822582

Mason, G. S., Shuman, T. R., & Cook, K. E. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. *IEEE Transactions on Education, 56*(4), 430-435. doi:10.1109/TE.2013.2249066

Mayer, R. E. (2002). Rote versus meaningful learning. *Theory Into Practice, 41*(4), 226-232. doi:10.1207/s15430421tip4104_4

Maykut, P., & Morehouse, R. (1994). *Beginning qualitative research: a philosophic and practical guide*. London: The Falmer Press.

Neuman, W. (2000). *Social research methods: qualitative and quantitative approaches* (4th ed.). Needham Heights: Allyn and Bacon.

Nguyen, B., Yu, X., Japutra, A., & Chen C-H. S. (2015). Reverse teaching: Exploring student perceptions of “flip teaching”. *Active Learning in Higher Education, 17*(1), 51-61. doi:10.1177/1469787415616727

O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *Internet and Higher Education, 25*, 85-95.

Pierce, R., & Fox, J. (2012). Podcasts and active-learning exercises in a "flipped classroom" model of a renal pharmacotherapy module. *American Journal of Pharmaceutical Education, 76*(10), 1-5.

Richardson, K. (1998). *Models of cognitive development*. Hove, U.K.: Psychology Press Ltd.

Rogoff, B. (1990). *Apprenticeship in thinking: cognitive development in social context*. New York: Oxford University Press.

Serdyukov, P. (2015). Does online education need a special pedagogy? *Journal of Computing & Information Technology, 23*(1), 61-74.

Snape, P. M. (2017). Enduring Learning: Integrating C21st soft skills through Technology Education. *Design and Technology Education: An International Journal, 22*(3), 48-59.

Taylor, J. T., & Bogdan, R. (1998). *Introduction to qualitative research methods: a guidebook and resource* (3rd ed.). New York: John Wiley & Sons Inc.

Vygotsky, L. S. (1978). Mind in society: the development of higher psychological processes. In M. Cole, V. John-Steiner, & E. Souberman (Eds.). London: Harvard University Press.

Zhu, Y., Wing, A., & Yates, G. (2016). University students' self-control and self-regulated learning in a blended course. *Internet and Higher Education, 30*, 54-62.