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Flipped classroom with cooperative learning as a cornerstone

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ABSTRACT

This article discusses the reasons for flipping a classroom in an Engineering course and for including cooperative learning, supported by the literature. The case study then notes the challenges in changing the teaching mode, for example, in building front-loaded resources, and in coaxing students into using them. Bloom's taxonomy enables constructive alignment, adding a significant third pedagogic adjustment. Evidence from students shows what worked and what didn't. Findings were likely to alert other lecturers attempting greater student engagement to what is entailed and to the commonality of time-expense when improving learning outcomes. Then student feedback on the learning experience was analysed to show their perspective on the changes, and to be used to fine-tune the course for a second cycle of action research. The results showed that flipped classroom helped to develop and improve students' learning and critical analysis skills. Furthermore, cooperative learning improved students' communication skills and enabled them to build their teamwork and problem-solving skills. More than 90% of students agreed that flipped classroom with cooperative learning enabled them to extend their skills. Nonetheless, we show how much work is required to achieve this, and what pitfalls lie in the way.

1. Introduction: the pedagogical problem that prompted change

Traditional lecture is the most common teaching method found in engineering universities worldwide. Traditional lecture approach is also called teacher-centred approach because the teacher does most of the work during the lecture (Bonwell, 1996). During a teacher-centred lecture, information or content is transferred from teacher to students. A teacher commonly stands up front trying to impart knowledge to a large group of students and; students watch and listen to their teacher mostly as passive recipients (Shakarian, 1995). Teacher-centred approach can be effective for presenting content in a quick manner and teaching students who learn best by listening. However, the teacher-centred approach has many limitations and presents several challenges, including that it treats all students as the same; students come to class with limited preparation; and formative feedback is often delayed (Tormey and Henchy, 2008).

Teacher-centred learning treats all students as the same: they are simply the audience. Yet, different students learn using different senses and prefer to learn different ways (Kolb and Kolb, 2005): some learn better by listening, others by reading, while others may learn better by doing and hands-on experience. Students also learn at different speeds. During a conventional lecture approach, some students find it slow-moving and grow bored while others get left behind. In both cases, students disengage from the topic.

During a traditional lecture, students commonly come to class with limited preparation. Students are assigned readings that a majority do not bother to read, because they are not put on the spot in class to show that they have learned from them. This means that students walk into the lecture with limited information about what to expect. Lecturers vary in skills at transmissive teaching, which impacts on how well students can follow along.

In larger classes, it is not logistically easy to give formative feedback, so it is often only during summative assessment that students become aware of gaps in their understanding or performance. Formative feedback on homework is often delayed while busy academics scurry to mark. Without much awareness of what they are doing right or wrongly, students take notes in class, and, later, practice rote learning and basic memorization that they hope will see them through examination. They often cram just before the exam. This results in superficial rather than deep-level learning (Marton and Säljö, 1976).

Student-centric approaches such as flipped classroom and cooperative learning can be viable solutions to deal with the pedagogical problems associated with the teacher-centric approach: they have

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potential to make learning more personal and dynamic. The limitations of the traditional lecture approach can be mitigated by shifting the activity of the classroom from teachers to sudents. Technology is used to flip the classroom by taking the transmitted information of the traditional lecture out of the classroom and redesigning it as the pre-class homework. Flipped classroom lecture time can be used for teacher-students interaction to promote creativity, enable new ways of critical thinking and problem-solving (Roehl et al., 2013). Additionally, cooperative learning or group work is another student-centric approach where students in small teams learn how to collaborate to solve problems. Cooperative learning with active student engagement means that students are more like to benefit from deep-level learning.

The literature about the flipped classroom with cooperative learning is still in an early phase of the development, and there are no clear patterns yet that have emerged about their effects on students learning. Furthermore, studies showing students' opinion about the flipped classroom with cooperative learning are rarely found in the literature.

In semester two, 2017, the lead author implemented the flipped classroom model with cooperative learning as shown in Fig. 1 as a cornerstone to deepen student learning, develop critical thinking and in the hopes that students might achieve improved learning. The course was Food Process Systems Engineering.

1.1. Flipped classroom

During flipped classroom approach, teachers design a digital resource of content, often a mixture of video recordings and readings, or a series of short video clips interspersed with readings and quizzes. They also should emphasise in the first class that engagement with this material is essential in the course. Students can watch from mobile devices at any time and come back to class with questions for the teacher, so they have more flexibility and the opportunity to learn independently. Keeping up with the class is no longer an issue for students who process ideas slowly, while faster-thinking students can avoid boredom.

Flipped classroom pedagogy has been extensively studied. For example, Bhagat et al. (2016) examined the impact of the flipped classroom on mathematics concept learning, Chao et al. (2015) explored students' learning attitude and achievement in flipped learning, Gilboy et al. (2015) showed that flipped classroom enhanced student engagement, and Horn (2013) explored the potential of flipped classrooms for transformational learning. Mason et al. (2013) implanted the flipped classroom model in an upper-division engineering course and compared its effectiveness to a traditional lecture approach. They concluded that inverted classroom model in a senior-level course in mechanical engineering was better for students' performances and grades. Love et al. (2014) compared the effectiveness of flipped traditional classroom models during a linear algebra course. Again, student course perceptions and content understanding were better in the flipped classroom model than in the traditional model. Previous research about flipped classroom pedagogy is mostly limited to specific disciplines or subjects (Betihavas et al., 2016), and to higher education context (O'Flaherty and Phillips, 2015). Other studies, Toto and Nguyen (2009), Herreid and Schiller (2013), and Talbert (2014), also compared flipped classroom models with the traditional teacher-centred model and found similar benefits.

Most studies confirm that flipped classroom help teachers to spend more time in-class on student-centric approaches, e.g., prompting student engagement through group discussion, and giving individual assistance to students (Bernard, 2015). Furthermore, they show some indirect benefits of the flipped classroom: it promotes independent learning, changes students' learning habits, and improve students' communication skills (Betihavas et al., 2016). A few authors such as Lo and Hew (2017) also argued that flipping the classroom at worst does not harm student performance and learning when compared with a traditional lecture or teacher-centred approach.

Flipped classroom pedagogy appears to be popular in engineering education. This observation may be due to the fact that engineering education requires the ability to use theory to solve problems. Lombardi (2007) argues that engineering education therefore requires problem-based constructive learning that requires student engagement, for example, as they work on projects. On the other hand, perhaps engineering education also needs traditional lecture approach to lecture on the theoretical background necessary for solving engineering problems (Karabulut-Ilgu et al., 2017). The flipped classroom is popular because it provides background information in the form of videos and problem-solving abilities by solving problems during the class.

Flipped classroom pedagogy has many challenges as well. This student-centric approach can require a considerable teacher workload of creating and designing flipped classroom content materials. On the other hand, this pedagogy can be relatively new for some students, and they can skip the pre-class activities and then find themselves lost in class. Students can also be dissatisfied with what they see as an unreasonably substantial amount of pre-class learning activities or preparation. Interestingly, Gundlach et al. (2015) concluded that traditional lecture approach performed much better than its flipped counterpart due to some of the reasons above.

1.2. Cooperative learning

Cooperative learning means students work together in a group and achieve both their individual and group learning goals through peer feedback and discussion (Johnson et al., 2007). During cooperative learning, students share their knowledge and learn from others in an organised and structured way, while instruction focuses on stimulating, coordinating and encouraging interactions among students (Shimazoe and Aldrich, 2010). Because students must find solutions in class with their peers, they are more self-aware of how well they are doing compared to others in the class. There's also more incentive to read the course material ahead of class. Students are no longer passive, but are learning actively, and learning how to manage their own learning rather than expecting to be spoon-fed.

Cooperative learning has many benefits to students and teacher. For example, it helps students to make progress in deep learning and critical thinking. They develop social and communication skills likely to be of use to them after graduation. Similarly, teachers can use cooperative learning class time to notice and reflect on students' learning. Some use of peer grading can lessen the grading load and at the same time make marking processes more transparent to students.

Previously, many authors implemented cooperative learning to gain better student engagement, improve learning outcomes for students, and developing team-work abilities among students. For example, Herrmann (2013) studied the impact of collaborative learning on student engagement in an undergraduate course, Johnson and Johnson (2008) reported improved learning as a result of cooperative learning, and Smith (1995) concluded that cooperative learning can develop efficient teamwork capabilities among engineering students. Other studies such as Springer et al. (1999), Hassanien (2007), and Roseth et al. (2008) have found that students put more effort into achieving their learning goals when involved in cooperative learning than when they learn alone as an individual. Dym et al. (2005) explained the importance of cooperative learning or group projects for engineering education, engineering design thinking, and learning. Felder and Brent (2007) advocated for various cooperative learning methods to maximise benefits and to

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