

Analysing student interactions in a flipped engineering course

Elaine Khoo

University of Waikato
New Zealand

Gareth Ranger

University of Waikato
New Zealand

Jonathan Scott

University of Waikato
New Zealand

Mira Peter

Ministry of Education
New Zealand

Flipped classrooms can support more open, flexible and collaborative student-centred learning. There is evidence that flipping learning can result in more effective learning processes and outcomes. However, not much is known about students' learning process in terms of their interactions while working collaboratively in a flipped class context. This understanding is essential to inform lecturers' timely and relevant facilitation of student learning. This paper reports on the findings from a study focused on the interactions, specifically types of talk, first-year undergraduate engineering students engaged in while collaboratively solving problem tasks in their practical lab sessions as part of a flipped class learning approach in a New Zealand university. Data were collected from a six-week video observation of student interactions. Herrington and Oliver's (1999) analytical framework on higher order, lower order, procedural, and social talk was used to analyse the video data. Findings revealed that the highest proportion of student interactions were procedural in nature followed by higher order, lower order, and finally, social talk types. These indicate the potential of the flipped class approach in fostering higher order talk in support of learning. Implications for practice are offered.

Keywords: Flipped class, engineering education, student interaction, dialogic process, talk analysis, problem solving

Introduction

Flipped classrooms have gained increasing interest and rapidly adopted in universities and various learning institutions worldwide. The flipped classroom is an active student-centred educational approach which typically requires students to prepare for class – through readings, pre-assessments, or watching videos – in order to gain basic information in their own time, prior to attending class/lectures. The class/lecturer time is thus freed up for students to apply the knowledge through problem solving activities with guidance from the teacher. Flipping the focus of class time allows students to take increased responsibility for their own learning through active investigation both in and outside of class time. This changes the class time focus and dynamics from the transmission of knowledge to one involving collaborative, interactive learning and just-in-time teaching (Bonk & Khoo, 2014). It provides more flexibility for lecturers and students to participate in discussion and collaborative and guided problem solving activities in ways that are known to address student misconceptions (O'Toole, 2013). The general findings from flipped class research appear consistently positive (Bishop & Verleger, 2013) and suggest that students are differentially suited to a flipped teaching environment.

Although active student learning and peer collaboration are essential in a flipped class context, a gap exists in understanding the quality of and how students are interacting to ensure they are well supported in a timely and relevant manner. This is important as others have found that not all students involved in collaborative group learning in digitally-supported contexts were able to engage in a productive collaboration process (Chang et al., 2017) implying that collaboration between students also needs to be trained or supported. Analyses of student dialogues can also importantly be used to determine the composition of collaborative groups or to inform guidelines for collaboration in technology-supported learning environments (Duque, Gómez-Pérez, Nieto-Reyes, & Bravo, 2015). With the exception of Miller et al. (2016) and Lin and Hwang (2018) very few studies have focused on analyzing student interactions in flipped classrooms.

This paper reports on a study focused on the analysis of student interactions as they engage in collaborative problem-solving tasks to understand their learning processes. The study is part of a wider two-year funded research project conducted to investigate the impact of adopting a flipped class approach on first-year engineering students' learning of threshold concepts in a New Zealand university. The next sections of this paper will describe the study context, research design, analytical framing and emerging findings from the study. The paper concludes with a discussion and recommendations for practice.

Research Context

The "Introduction to Electronics" course is a compulsory undergraduate course for engineering students at the University of Waikato, New Zealand. It has a typical enrolment of approximately 150 first-year students and is co-taught by two lecturers. The course is regarded by many students to be a conceptually challenging one with a relatively heavy conceptual load, particularly in the analog electronics section. The organisational model for this course has traditionally consisted of three one-hour long lectures, an hour-long tutorial session, and one three-hour laboratory session each week of the semester. It is expected that all students would attend all lectures. Each student is expected to attend one of 5 parallel laboratory streams which run once a day on each day of the week.

Research Design

The research team consisted of collaborations between two educational researchers and the two course lecturers. In the project, a design-based research approach with practitioner-led cyclical processes of planning, design, and implementation was adopted to develop, trial and evaluate the flipped class approach (Collins, Joseph, & Bielaczyc, 2004). Components of the flipped class design included:

- Lecturer-developed instructional videos. The videos were a combination of "Khan-Academy-style" videos lasting between four to 13 minutes long as well as those developed using PowerPoint and PowerPoint add-ons with embedded quizzes. The videos were created with careful reference to recommendations from cognitive principles shown to be effective in multimedia learning (Sorden, 2005). Completed videos were then linked into the course Moodle site. Students could access, view and review the videos to engage with the new course material outside of class time.
- Continuous assessment. Traditionally in the course, students were assessed through two quizzes and a final exam. In the flipped class intervention, students were assessed continuously either biweekly or weekly depending on the length of a semester.
- Online tutorials. Students were required to complete a series of online tutorials that gave them practice in understanding basic concepts.
- Problem-solving activities. From the onset of the study, the lecturers created problems relevant to particular weeks' videos and the practical lab work. During the face-to-face in-class (practical lab) time, students worked in pairs or in groups of four to solve these problems, with lecturers and tutors at hand to help. Students could re-watch the instructional videos while solving these problems or during the lab work. Lecturers also devoted some of the lab time to conduct 10–15-minute mini-lectures to address students' questions or in relation to test results.

Five cycles of the flipped class approach were progressively implemented over a two-year period with increasing refinements made to enhancing the course design, materials, and assessment based on the results of the previous cycle. This paper focuses on the data collected in the fourth iteration of the intervention. In this iteration, the class was fully flipped in that students no longer attended lectures but had to watch the instructional videos prior to attending their practical lab sessions. This study thus aimed to obtain a deeper understanding of student interactions with their peers while working collaboratively to solve problem tasks within the fully flipped class context.

Data Collection and Analysis

Multiple data sources were collected in each flipped class cycle but for the purposes of this paper and due to limits of space, only the analysis of video data will be reported. Other aspects of the flipped class design and learning outcomes have been reported elsewhere (AUTHOR 1).

The course was offered over the summer semester and was a more compressed version of the regular semester; across a shorter six-week period. Fourteen students enrolled in the course. Of these six students (three pairs) consented to being videoed while working collaboratively with their lab partners during the practical lab sessions as part of their flipped class learning. The research team videoed their interactions and discussions over the six-week period for an hour each time. However only interactions from five weeks were considered for analysis. Their discussions were transcribed and analysed using a combination of Nvivo software and Microsoft Excel. The research project received formal university-level human research ethics approval.

Analytical Framework

The video data was analysed based on an adaptation of Herrington and Oliver's (1999) coding scheme (see Table 1). Their original study investigated preservice student teachers' levels of higher order thinking while working through an interactive multimedia programme. Adopting a situated learning theoretical frame, they analysed student talk as they engaged with the programme. Table 1 presents each type of student talk, their descriptions and examples of student talk that guided the analysis. Higher order types of talk refer to the kinds of talk students engage in while considering new information, relates this to and/or extends this new information to achieve a learning goal. It can be further delineated into six other kinds of sub-talk; imposing meaning, judgement, metacognition, multiple perspectives, paths of action and uncertainty. Although these six characterisations of student talk offer a useful analysis of higher order student talk. Herrington and Oliver further proposed a coding scheme to distinguish these from non higher order talk: Social, Procedural and Lower order talk types. We adapted the scheme (higher order, lower order, procedural, and social) to suit our flipped class context of student pairs working collaboratively to solve problem tasks and having access to resources such as the flipped class videos through the computers in the lab or on their mobile devices; the tools/resources available to them in the lab as well as being able to approach the lecturer/tutor for assistance. The main adaptation was in the Procedural category which is a non-talk category that considered student actions in using the equipment, software, computer to complete their learning task.

Table 1: An adaptation of Herrington and Oliver's coding scheme on higher order talk types

Types of interactions	Sub-category	Description	Example
Higher order	Imposing meaning	Student talk that raises a possible solution to a problem or suggests alternative solution. Usually expressed as a summary, decision or a new idea, or a conclusion.	'I guess if you were looking at the bulbs separately, they would count as being "in series", but...'
	Judgement	Student talk that attempts to interpret and defend his/her understanding of an issue.	'to me though, that [points to image] would be in parallel with that, and that would be parallel with that...'
	Metacognition	Student comments which indicate his/her awareness of own thinking and performance, and comments related to the use of this awareness to improve performance.	'Oh no, I divide that by six instead...'
	Multiple perspectives	Student talk that suggests an alternative approach or challenges a conclusion/ previously made point by providing an alternative perspective.	'You could actually just use a 99 Ohm resistor...Yes, but using a number that actually exists.'
	Deciding on a path(s) of action	Any student talk proposing actions to take, e.g., What parts of the problem to solve, decisions about what to write in lab books and negotiations of how to proceed.	'So LP1 is not going to change, the resistance across there [points to image] will remain the same'
	Uncertainty	Any student talk which expresses some uncertainty about an approach to adopt, a course of action, or any expression of dilemma or uncertainty.	'..so the tutor is doing 3 plus 1000, rather than 3 times 1000 so V equals...No, wait...'

Non higher order	Lower order	Any student talk which is routine, requiring little thought, or the mechanical application of well-known rules.	Reading a question/ problem aloud, or repeating basic principles of electronics.
	Social	Talk between lab partner or with other students that can either be; (i) off task (not related to the subject), or, (ii) on task (social statements which relate in some way to the task).	Discussing the weather, or a grade received in another paper
	Procedural	Actions involving the use of equipment, software, computer that is related in some way to the task.	Reading the problem sheet or their own notes, writing task-related notes in their lab book, using a digital device or a calculator, watching the flip videos, or searching online for answers.

The unit of analysis for coding student talk was based on the unit of meaning focusing on a single thought, idea, argument or information regardless of its length (Henry, 1992). The coding was conducted by a member of the research team and verified by other team members.

Findings

The overall findings indicated that across the three pairs of students, procedural interactions were most commonly exhibited by students (37%), followed by higher order (28%), lower order (22%), and social types of talk (13%) (see Figure 1).

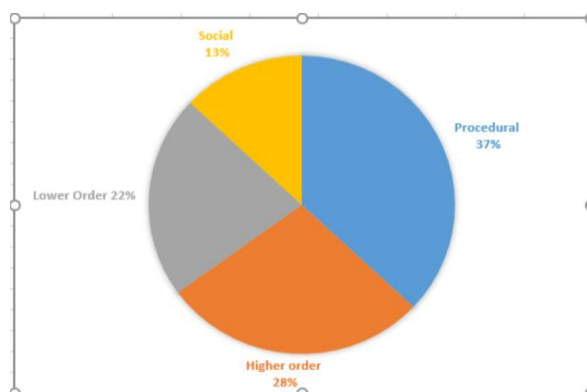


Figure 1: Overall interactions

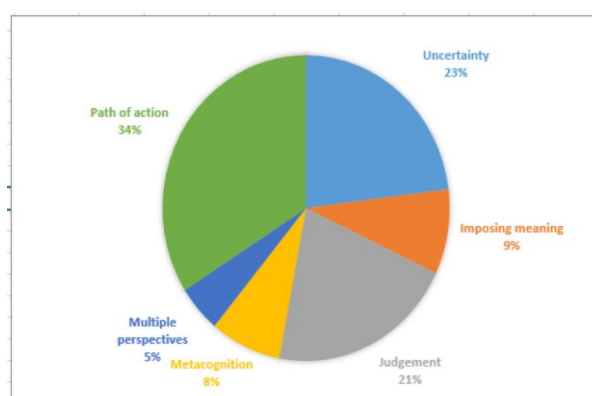


Figure 2. Types of higher order talk

Analysis of higher order talk between the student pairs revealed 'Path of action' (34%) was observed most often (see Figure 2). This talk involved decisions about which parts of the problem to solve, decisions about what to save in the note book and negotiations of how to proceed to solve a problem task. 'Uncertainty' was the second most common higher-order talk type (23%) followed by 'Judgement' (21%), which refers to students' attempts to interpret and defend their understanding of the issues presented in the assessment program. These three talk types denote the fact students are actively interacting with their peer to solve task, voiced uncertainties to clarify confusion or dilemma before making a judgement to defend their opinions. A comparison of the frequency of higher order and lower order talk indicated that they both varied over the duration of the course. The variations in the amount and the quality of discussions mostly depended on the requirement of the problem that was being discussed to elicit either a higher order or more procedural talk type. Investigation into the social talk type revealed students engaged in on-task more often (52%) than off-task (48%) talk.

Discussion and Conclusion

This study investigated the types of student talk to evidence their learning in a flipped classroom. Implications for practice exist from the findings. In successful technology-supported learning environments there needs to exist different levels of interactions between student-content, student-teacher, and student-student (Bonk & Khoo, 2014). Our work indicates this to be the case for student-peer interactions. The findings also dispels common misconceptions and tendencies to think that all that is needed for a flipped class to work is to prepare videos and relevant resources for students to access before attending a class. Our findings, as well as those of others, indicate that a focus on both before-class preparation and in-class work are of essence (Roach, 2014). Our findings highlight that student procedural actions in the problem solving task sessions to be an important part of informing their work and in their interactions with peers. This places value on the kinds of resources (digital and/ or physical equipment) that they can draw from. For example, the type and characteristic of the problem task assigned to students is a consideration as it can promote either higher order talk or procedural type interactions. The instructional videos assigned to students to watch prior coming to the labs also need to be relevant to the class problem solving activities and practical lab work for each week. A coherent course design with clear and explicit connections between course elements and resources are therefore fundamental to enhance students' productive talk, understanding and application of ideas.

The findings also support lecturer and student changing roles. A common issue in the flipped class approach is that first year students from traditional educational backgrounds are unused to the greater degree of self-directed learning and responsibility required. By understanding the kinds of higher order talk supportive of student learning, lecturers can offer guidelines and assist students to identify and model what these might look like as part of helping them develop awareness and learn to take a more active role and responsibility for their learning. Lecturers need to relinquish traditional role of 'telling' to become a facilitator of student learning, placing value on students interacting with their peers productively as part of learning. The course structure and teaching-learning activities need to be streamlined to support students' increasing responsibility for their own learning.

As flipped classrooms are increasingly adopted in tertiary settings, the findings from our study highlight that understanding the ways students interact with one another and the quality of their talk can offer a productive approach to identify and establish more timely and relevant pedagogical and learning supports to maximise their learning opportunities and outcomes.

Acknowledgment

The authors gratefully acknowledge funding support from the Teaching and Learning Research Initiative, New Zealand Council for Educational Research, Wellington, New Zealand.

References

- Bonk, C. J. & Khoo, E. (2014). Adding some TEC-VARIETY: 100+ Activities for motivating and retaining learners online. Retrieved from <http://tec-variety.com/>
- Bishop, J. L., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. Paper presented at the 120th American Society of Engineering Education Annual Conference & Exposition, Atlanta, GA. <https://doi.org/10.18260/1-2--22585>
- Chang, C. - J., Chang, M. - H., Chiu, B. - C., Liu, C. - C., Fan Chiang, S. - H., Wen, C. - T., ... Chen, W. (2017). An analysis of student collaborative problem solving activities mediated by collaborative simulations. *Computers & Education*, 114, 222-235. <https://doi.org/10.1016/j.compedu.2017.07.008>
- Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *The Journal of the Learning Sciences*, 13(1), 15-42. https://doi.org/10.1207/s15327809jls1301_2

- Duque, R., Gómez - Pérez, D., Nieto - Reyes, A., & Bravo, C. (2015). Analyzing collaboration and interaction in learning environments to form learner groups. *Computers in Human Behavior*, 47, 42-49. <https://doi.org/10.1016/j.chb.2014.07.012>
- Henri, F. (1992). Computer conferencing and content analysis. In *Collaborative learning through computer conferencing* (pp. 117-136). Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-77684-7_8
- Herrington, J., & Oliver, R. (1999). Using situated learning and multimedia to investigate higher-order thinking. *Journal of Interactive Learning Research*, 10(1), 3-24.
- Lin, C. J., & Hwang, G. J. (2018). A learning analytics approach to investigating factors affecting EFL students' oral performance in a flipped classroom. *Journal of Educational Technology & Society*, 21(2), 205-219.
- Miller, K., Zyto, S., Karger, D., Yoo, J., & Mazur, E. (2016). Analysis of student engagement in an online annotation system in the context of a flipped introductory physics class. *Physical Review Physics Education Research*, 12(2), 1-12 <https://doi.org/10.1103/PhysRevPhysEducRes.12.020143>
- O'Toole, R. (2013). Pedagogical strategies and technologies for peer assessment in Massively Open Online Courses (MOOCs). Discussion Paper. University of Warwick, Coventry, UK: University of Warwick.
- Roach, T. (2014). Student Perceptions toward Flipped Learning: New Methods to Increase Interaction and Active Learning in Economics. *International Review of Economics Education*, 17, 74-84. <https://doi.org/10.1016/j.iree.2014.08.003>
- Sorden, S. D. (2005). A cognitive approach to instructional design for multimedia learning. *Informing Science: International Journal of an Emerging Transdiscipline*, 8, 263-279. <https://doi.org/10.28945/498>

Please cite as: Khoo, E., Ranger, G., Scott, J., & Peter, M. (2019). Analysing student interactions in a flipped engineering course. In Y. W. Chew, K. M. Chan, and A. Alphonso (Eds.), *Personalised Learning. Diverse Goals. One Heart. ASCILITE 2019 Singapore* (pp. 470-475).