Learning threshold concepts in an undergraduate engineering flipped classroom

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Abstract

Given that the current goals for tertiary education is to better prepare students to apply their disciplinary knowledge in the real world and novel situations, it is imperative that students master the necessary disciplinary threshold concepts and competencies. Building on the findings of our pilot study of a partly-flipped undergraduate electronic engineering course, a version of a fully flipped is implemented in an intensive six-week version of the course involving in-class collaborative problem solving and continuous assessment. Data collected from the 32 students enrolled in the course include student surveys, video analytics, weekly student assessments, class observations and a focus group interview. Although data collection is still underway, the emerging findings indicate that students are watching the recommended weekly videos prior to coming to class and are solving online tutorials problems much more diligently, resulting in higher levels of in-class student collaboration compared to the pilot study. The results are discussed in regard to the effects of the fully flipped class model and the continuous assessment on students' learning of threshold concepts and competencies.

Introduction

Within each academic discipline there exists concepts, threshold concepts (TCs), that once grasped can reveal new and previously inaccessible ways of thinking about that subject (Meyer & Land 2003). These concepts are hard-to-grasp, troublesome, and are often where students 'get stuck' (Harlow, Scott, Peter, Cowie, 2011) yet students need to master them in order to think and act like subject specialists. There is a growing evidence that structuring tertiary curricula around TCs can help students learn more effectively (Wolf & Akkaraju, 2014, Peter & Harlow, 2014) and that a flipped classroom model of teaching and learning can foster more active student learning (McLaughlin et al., 2014).

In a flipped class, lecture materials are assigned as take-home tasks that students are required to do prior to coming to the class. The class time is thus freed up for active in-class student inquiry and collaboration, such as small group problem-solving and discussions, and to address student questions and misconceptions (Strayer, 2012). These activities have been shown to help students master TCs (O'Toole, 2013). By flipping the class the lecturer's role changes to that of a facilitator of learning through observing and monitoring areas in which students need help with; providing students with different ways to learn content and demonstrate mastery; giving students opportunities to actively participate in meaningful learning activities; scaffolding these activities and making them accessible to all students through differentiation and feedback; and conducting ongoing formative assessments during class time (Hung, 2015; Chen, Wang, & Chen, 2014; McLaughlin et al., 2014, Kim, Kim, Khera, & Getman, 2014; Halili et al., 2013).

Our study addresses these recommendations through an emphasis on students watching pre-recorded videos, solving online tutorials problems, attending in-class mini-lectures and participating in continuous assessment and collaborative problem-solving tasks. These provide a variety of ways for students to learn and demonstrate mastery of TCs and related concepts.

The problem being addressed

The Introduction to Electronics course is a core undergraduate engineering paper compulsory for all engineering students. 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. Each student was expected to attend all of face-to-face lectures and tutorials and one of five laboratory streams which run once a day on each day of the week. The course is regarded by many students to be a conceptually challenging one with a relatively heavy conceptual load. Earlier studies by our research team (collaborations between two educational researchers and the two engineering lecturers teaching the course) evidenced the effectiveness of refining the course curriculum to emphasise student learning of TCs (Scott, Harlow, & Peter, 2012) and the implementation of an online tutorial system to replace the face-to-face tutorials (Peter, Harlow, Scott, Balsom, & Round, 2014). As the online tutorial system was well received by students, the team decided to extend the research to incorporate more online learning resources and active student participation as recommended through the flipped class approach. It is expected that a TC-based flipped-class approach to teaching and learning would enhance students' learning of threshold concepts and competencies.

Study design/Approach

The current project builds on our pilot study (Khoo, Peter, Cowie, 2015). Over three weeks, three 50-minute lectures were replaced with a suite of short lecturer-created videos focusing on TCs. The videos, (4-13min) were created. These were designed using recommendations from cognitive models shown to be effective in online learning (Sorden, 2005) and resembling khanacademy.org-style videos. Students accessed these from the course using Moodle as the LMS.

The results of the pilot showed that students' achievement in the flipped class section of the course could not be predicted from their viewing of the video materials. Although over 90% of students found the videos helpful, only about half of students thought the videos' content was well matched to the lab's activities (48%) or that it helped with practical application in the lab (54%). These results suggested that the strategies for motivating students to watch the videos and be prepared for the class needed to be reviewed and that stronger links between the video materials, in-class activities and laboratory work needed to be established.

In the current study, the partly-flipped course in the pilot study was replaced by a fully flipped course which incorporated more explicit connections between course elements, enhanced in-class collaborative problem-solving tasks, continuous assessments, and student postings of questions, from their video-watching, in the Moodle forum to inform the in-class mini lectures. It is expected that these refinements would increase the number of videos watched prior to each face-to-face class and more timely use of online tutorials to support learning in general and the learning of TCs in particular. Qualitative and quantitative data are being collected from student focus group interviews, surveys, observations, video-watching analytics and online tutorials completion rates. The weekly assessments are being collected and will be analysed for the indicators of students' learning of TCs.

Findings

It was anticipated that current refinements to the flipped class and especially the introduction of continuous assessments would increase the average number of videos that students watch prior to each face-to-face class. Emerging results seem to support this expectation. Students have reported that the continuous assessments have encouraged them to diligently attend to all learning materials and make connections between various educational resources in the course.

An increase in the quantity and the quality of in-class discussions and efficiency of student problem solving attempts is also expected. Classroom observations and lecturer reports thus far suggest that this is the case. Informal reports from the lecturer indicate that students are using the Moodle forum to pose questions and also to share resources with one another. These observations will be further examined during the focus group interview.

Overall, we expect that better learning outcomes will be achieved in terms of TCs and higher overall grades than the previous cohort of students in the pilot study. We also expect that students will experience greater satisfaction with learning through the flipped class approach than students in the pilot study (Khoo, Scott, Peter, & Round, 2015). The outcomes of the data analyses will be reported in our conference presentation.

Discussion and conclusion

In this study, students in a fully flipped class can draw from a variety of teaching and learning resources—pre-recorded videos, online tutorials, mini lectures, posting questions on Moodle, continuous assessment, group problem solving, and practical lab work—to help them learn TCs.

By incorporating continuous assessment to encourage prior class preparation and by making more explicit the connection between the different course elements (online tutorials, videos, weekly tests and practical group work), students are more motivated to continuously learn and can see the "whole picture" within the course. This also confirms findings from others who have trialled continuous assessment as part of the flipped class approach (Kim et al., 2014). We argue that when assessment is continuous and formative, it becomes part of mastery-based learning (Gagné, 1988; Hernandez, 2012; Khan, 2012; McNabola & O'Farrell, 2014) and that it is this aspect of the flipped class that can contribute considerably to students' learning of TCs. In our study continuous assessment served three main goals: (1) to reinforce students' timely video materials viewing and practicing using online tutorials, thus assisting in pacing learning, (2) to reinforce or correct learned responses, and (3) to improve the quality of students' learning of TCs. Further examination of the effects of the continuous assessment in a fully flipped class may identify additional ways to refine and improve this approach to teaching and learning in the next phase of the project.

Offering students the opportunity to post questions related to their video watching helped to inform the lecturer about the areas where students needed specific help. The in-class mini lectures addressed these areas and provided opportunities for further questions and enhanced collaborative work and solving online tutorial exercises. Through in-class mini lectures students' concerns are addressed in a timely manner to benefit their and their peers' learning. In successful blended or technology-supported learning environments there is a need for different levels of interactions between student-content, student-teacher, and student-student (Bonk & Khoo, 2014; Moore, 1989). Our work indicates this to be the case. It 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 essential (Chen et al., 2014; McLaughlin et al., 2014; Roach, 2014). A coherent course design, continuous assessment and feedback, and more explicit connections between course elements are all necessary to enhance students' understanding and application of ideas concerning TCs.

To conclude, it is expected that the findings from this study will deepen our understanding of the ways and extent to which a flipped class model can foster a more meaningful learning of TCs, and inform pedagogical practice and theorising in engineering and potentially in other disciplines.

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