

Introduction

Students in Undergraduate Research Degrees (URD) offered by the Australian National University, such as the Bachelor of Engineering (Hons) (Research and Development) (BE R&D) are high performing and have obtained an Australian Tertiary Admission Rank (ATAR) of 99 or above to be admitted to the degree programs. These URDs have the requirement that students must achieve First Class Honours to graduate from the program, of which a High Distinction (HD, > 80%) average is indicative. Not all URDs stipulate a HD requirement, however, in the BE (R&D), a HD average grade is a requirement. As such, the students become fixated on their grades, focusing on rote memorisation, which compromises the quality and depth of their learning, as well as their personal development. As a result, we have found, in our combined experience of eight years with the BE (R&D) students at ANU, that they have underdeveloped reflective, interpersonal and critical analysis skills. The underdevelopment of these skills will have a significant impact on engineering graduates and compromise the quality of the next generation of innovators and leaders in society.

Therefore, there is a great need to engage URD students and develop higher order skills that will enrich their learning whilst also developing their 'soft skills' producing more reflective and interpersonally skilled graduates, a problem that is faced by science as well as engineering faculties (A. N. Wilson, Howitt, & Wilson, 2012). We propose that engagement-based teaching strategies can increase student engagement, encourage independent learning attitudes and facilitate deep learning. Our implemented engagement-based strategies include a flipped classroom and individual feedback sessions with each student in the course.

Background

ENGN2706 Engineering Research and Development Project (Methods) is a course where each student completes an individual research project, with an academic supervisor. This research aspect is inherently student-centered as it is project-based, where the students attempt to develop and answer research questions independently (Pedersen & Liu, 2003). In ENGN2706, research methods are taught concurrently to the execution of the research project. In previous years, this aspect of the course has been teacher-directed and the delivery employed the transfer theory style of teaching (Fox, 1983), where concepts and information were conveyed to students through traditional one-hour lectures. This delivery required limited peer interaction and resulted in decreasing student engagement and satisfaction. In 2014, the course was modified to encourage student independence, specifically by not providing assessment rubrics, however, this was not well received by students. Student satisfaction (from ANU Student Evaluation of Learning and Teaching (SELT) scores) decreased from 82% (2012) to 78% (2013) and finally 63% (2014). Combined with our observations of student characteristics and development, the decrease in student satisfaction indicated that the teaching method needed to change.

A key area of development that we identified in BE (R&D) students is a lack of initiative associated with their learning at university. A new area of investigation in university education is online delivery of content, through methods such as a flipped classroom, to enhance student learning and engagement. Therefore, we have investigated the effect of 'flipping the classroom' on student engagement and learning attitudes.

In this course, the 'flipped classroom' approach was modified, where the course content, previously presented in face-to-face lectures was presented as short (5 minute) videos available online from the commencement of the course. Students were expected to watch the relevant videos before each engagement session (two sessions a week), where they had face-to-face time with the course facilitator. All students were completing individual projects, so although these engagement sessions interactively explored course content, they were unable to cater to the individuality of student projects, and so are not the focus of this paper.

Methods

Course content was presented in 5-minute videos. These videos were prepared before the course commenced and were uploaded to the Web Access To Teaching & Learning Environments (WATTLE) site for the course. The number of views of each video was obtained from the WATTLE reports tool.

Three individual feedback sessions were held in weeks 3, 6 and 12 of the semester, where students had 10 minutes to talk to the course convenor and facilitator to discuss their project progress, their course experience and any concerns they had.

These strategies were evaluated through student responses in their weekly online learning logbooks, where they were asked to reflect on the online videos and the individual feedback sessions at the end of the course.

All aspects of this project were approved by the ANU Human Research Ethics Committee, protocol 2015/032.

Results

Adapting lectures to a flipped classroom: 5-minute online video format

Through the online learning logbooks, students expressed many common reasons for why they found presenting course content in videos online was effective. The explanations included feedback that videos: 1) were succinct, 2) provided sufficient preparation for in-class discussions, 3) allowed more time for discussion in class, and 4) provided flexibility and fostered independent learning.

Succinct videos

5-minute videos were developed to prevent students' dis-engagement whilst viewing. Student responses to the videos indicated this was effective, as they felt the video length allowed them to absorb the content, whilst also presenting important content. Their length limited the content covered in individual videos, sometimes resulting in multiple videos covering one larger topic. Students preferred the content to be broken down into individual topics, highlighting the effectiveness of this delivery method compared to lectures that cover multiple topics briefly.

*"I don't often go back and watch **lectures** again however because they (videos) were short and I was supposed to be watching them online anyway I was far more inclined to go back and watch them more than once."* (emphasis added)

*"I would prefer 60 minute lectures to be broken down into 6 short videos... I am **sure that I retain** more from this style of learning."* (emphasis added)

Many of the students echoed this sentiment, indicating that the traditional lecture-style delivery method needs to be re-evaluated in order to meet students' learning needs. Although there has been disagreement in the literature over students' attention span in lectures (Matheson, 2008; K. Wilson & Korn, 2007), ENGN2706 students' self-assessment revealed that they can more easily pay attention to short, concise videos compared to lectures. Students also reported that an increasing workload compromised their lecture attendance. The authors would like to note that there are many factors that affect students' attention in lectures, such as interactivity, content, teacher presence and external pressures. However, succinct videos also offer added benefits such as flexibility and opportunities to develop independent student learning, as is explored next, in addition to the fundamental pedagogical "work" of conveying content.

Treating videos as preparative material for in-class discussions

Each week students watched a specific set of videos that would relate to the discussions held in-class. Therefore, the videos were treated as preparative material for in-class discussions, which helped increase student understanding of what would be covered each week, and allowed them to develop their own thoughts beforehand:

*"(The videos) not only provided us with useful background information prior to the class, watching them prior to the class meant that we had a good understanding of what the discussion would be based on. Furthermore hearing a discussion on the topics beforehand **allowed us to really think about the topic and develop our own thoughts**, ideas and opinions which could then be discussed in the sessions."* (emphasis added)

*"Watching (videos) before (engagement sessions) meant that I could have a think about the topic of the engagement session **before** coming."* (emphasis added)

"(the videos allowed) us to sit down and absorb the material fully, rather than being rushed through a lecture and then having to fill in the gaps later"

This indicates that treating course content as preparative material for in-class discussions encourages students to engage with material. Previously, traditional lectures have focussed on the transfer of content to students, with little follow-up. However, the videos presented online in ENGN2706 not only provided content for students to learn, but also encouraged them to think deeper to prepare for the activities that would follow in the engagement sessions. Hence, the students were beginning to operate in the knowledge deepening domain of *analysing*, whilst also extending to the *evaluating* and *creating* domains of Bloom's revised Taxonomy of Learning (Krathwohl, 2002)

Videos allowed more time for in-class discussion

Following on from being effective preparation material for class discussions, students also identified that covering course content in videos allowed for more time in the engagement sessions for discussions:

*"(The videos) freed up engagement sessions to be more involved in discussion, **developing deeper** understandings of topics, asking well thought out questions. This also allowed for increased **engagement** with the group, facilitator and convenor rather than **focussing on memorising** new content. In this sense, presenting the course content through short videos allowed the engagement sessions to become a more **valuable** source of learning based around taking course concepts further, rather than **simply** introducing content."* (emphasis added)

*“Most of the content covered in the videos tended to be simple but important concepts that needed to be addressed so it left the engagement sessions available for more **in depth discussion** regarding those concepts.” (emphasis added)*

*“...during the engagement session everyone could **focus on discussing** the content, rather than learning it for the first time.” (emphasis added)*

*“(After watching the videos) we had the content in our minds already before coming to the engagement sessions, allowing for group/class discussions to be used. These discussions further helped our learning since we were made to **think deeper** about the material than **simply being lectured** to, so it gave us a chance to have **our own input** to the learning material.” (emphasis added)*

*“I found (watching the videos beforehand) meant **I had time to think of questions** or prepare general comments before class time, instead of realising something didn't make sense after class time.” (emphasis added)*

*“Too often I find myself trying to understand the content in a lecture rather than forming thoughts and opinions on it. By watching a short video that orientated me on the topic beforehand, I thought that **I became more confident** with the topic and was able to present an opinionated view on the content.” (emphasis added)*

Student participation in classes such as tutorials is dependent on a variety of factors including student-teacher and peer dynamics, as well as the design of class activities. However, student feedback suggests that allowing them to prepare properly for classes, through materials such as online videos, is a factor influencing students' participation and warrants further investigation.

Videos provide greater flexibility and independence of learning

“Flipping the classroom” and providing the videos online gave students a greater sense of independence and a degree of flexibility not currently experienced with previous traditional lectures in ENGN2706. Flexibility in learning is becoming an important factor at university, particularly in accommodating timetabling clashes and student commitments such as casual jobs, as well as catering for the different rates of learning amongst students. As such, presenting videos online achieved such flexibility for students in ENGN2706:

“It allowed us to choose a time that was suitable for us (to watch the videos)”

“Since we can watch these videos and take notes anytime we want, it is very convenient.”

“I think it was rather useful because of how I could replay, rewind, etc. the videos even after the associated engagement session.”

Not stipulating a time by which the videos had to be watched (only the session by which students should have watched them) also encouraged student independence, as they had to be proactive and watch the videos to learn the content. This proactive behaviour was also encouraged as engagement session activities were designed around the video content. Therefore, if students wanted to be able to participate in the activities and have a positive

contribution, they had to watch the videos beforehand. In addition to encouraging proactive behaviour, the availability of videos online allowed for easy access the entire duration of the course, fostering independent learning attitudes:

*“It allowed for **independently learning** the course content, and being able to, for example, search up additional information that could be related back to the content.” (emphasis added)*

*“It was a delivery format where I could **easily go back if I missed something**, unlike a lecture environment (especially if the recording system fails) where I sometimes find it difficult to keep up with the lecturer. This meant that I could **try and resolve most of my own questions** as I could go over points of concern multiple times via replay.” (emphasis added)*

“It was also good to be able to re-watch them a few times if we **needed** a quick refresh on what was covered.” (emphasis added)

Delivering properly designed resources (such as brief, online videos) can provide a foundation for independent student learning. The flexible nature of videos being available online contributed to independent student learning in ENGN2706, however, we would also like to note that the resources need to also be engaging for students. If students do not find online resources engaging (similar to not finding some lectures engaging), they are unlikely to utilise them to their fullest extent, and hence, the benefit of flexible learning resources is not reaped.

Most viewed videos correspond to important assessment items

The average viewing of each video per student is showed in Figure 1. The top 5 most viewed videos are highlighted, and with the exception of the first, research methods, they all corresponded to assessment items in ENGN2706. The research methods video was the first video covering content in the course and, since it is the first research project students have conducted, it is reasonable that they would watch it multiple times (an average of 3 views per student).

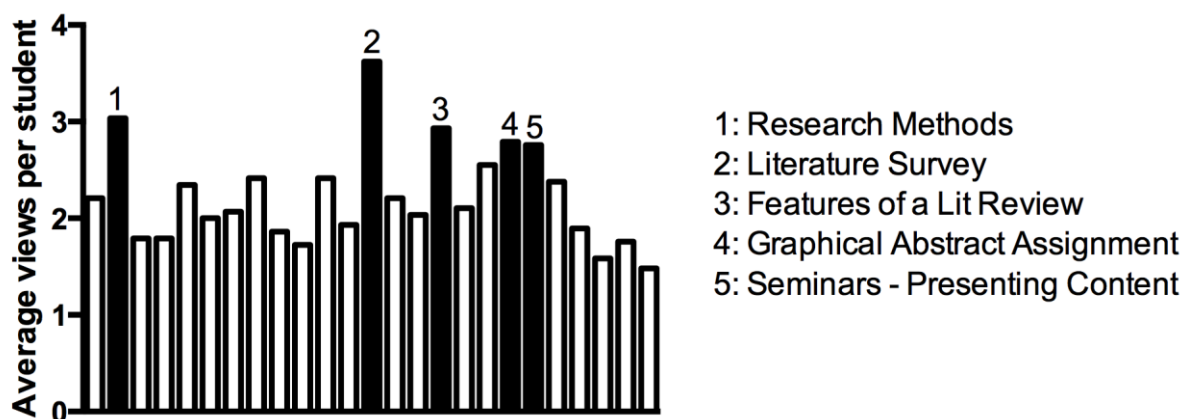


Figure 1: The average number of views for each video presented throughout the course. Numbered videos had the highest views, corresponding to videos on: 1. research methods, 2. literature surveys, 3. features of a lit review, 4. graphical abstract assignment and 5. Presenting content in seminars

The video corresponding to how to write a literature survey had an average of 3.6 views per student, which was also an individual assignment, worth 10% of the final grade. Students remarked that before the video, they did not know how to start a literature survey and that their concept of literature surveys was “quite blurred”. The video ‘Features of a Lit Review’ was also

frequently watched, with an average of 2.9 views per student. This video was a conversation between the course convenor and facilitator about their experiences of writing and reading literature reviews, as well as common mistakes from previous students' work. These two videos addressed what students found one of the most challenging pieces of assessment in the course. No student had written a literature survey before and most of them had never read academic papers prior to ENGN2706. Thus, providing and clarifying information that was readily available online was found to be valuable by students; furthermore, students then requested videos specifically addressing individual pieces of assessment.

The video on the graphical abstract assignment detailed the assignment logistics (it consisted of peer reviewing draft graphical abstracts and responding to reviews), with an average of 2.8 views per student. The video on presenting content in seminars had an average of 2.7 views per student. These videos correspond to the two assessment items (external to the final report) due in the second half of semester. The value students placed on these videos, as well as having the information available for students who missed an engagement session, were the two drivers behind assignment related videos. This trend demonstrates the benefit of presenting content online to foster independent and flexible learning.

Providing regular individualised feedback to students

In addition to providing online videos to student, three individual feedback sessions with each student were held throughout the semester. Students identified four benefits of having three individual feedback sessions with the course convenor and facilitator: 1) the opportunity to voice their opinions or concerns, 2) personalised feedback, and 3) the reflective nature of the sessions.

Voice opinions or concerns

Students valued the opportunity to communicate directly any concerns they had with the course convenor and facilitator:

*“If I did have any questions about the course, I was able to comfortably raise these during the individual feedback sessions. This made me feel secure in the knowledge that **my feedback was not simply being lost** in a bureaucratic system but rather was being directly heard by those in charge.” (emphasis added)*

Student feedback to the course convenor and facilitator contributed to the evolution of the course. Creating an environment in which students felt comfortable voicing their concerns also allowed for an immediate discussion, increasing the understanding of the situation. This is a benefit of having face-to-face feedback sessions compared to written forms, and can also allow for potential solutions to be discussed with the student. In these sessions student concerns were acknowledged and changes to assignment deadlines, or explanations of assignments were made accordingly, to improve student experience and understanding of the course.

Personalised feedback

Personalised feedback is uncommon in most courses the BE (R&D) students complete at ANU, however, it was found that students appreciated the opportunity to receive individualised feedback:

*“The individual feedback sessions are **truly unique** to this particular course thus far in our education. Throughout the entirety of our learning both at school and university, information*

*and feedback was usually **passed on for the masses**. However in 2706 there was a very unique method of giving students feedback. In hindsight I truly believe the individualized feedback sessions was an **excellent method of communication** between the students and the course convener.” (emphasis added)*

The personalised feedback fostered an environment of engagement between students and the course convenor and facilitator. Each student was completing a unique research project and so personalised feedback was an appropriate method of providing feedback. Learning about research and executing their first research project was challenging for students, so the opportunity for them to receive personalised feedback that helped target areas that were specific to their development was found to be beneficial for students. Personalised feedback sessions are also advantageous as they account for the individuality of each student, their learning experiences and their learning styles. Students felt more connected to the course as there was a greater degree of engagement between themselves and the course convenor and facilitator compared to their other courses. Although time consuming, individual feedback sessions were found to be of value by both the students and the course convenor and facilitator.

Reflective nature

Reflective practice is an important skill for researchers, however it has previously been overlooked in ENGN2706. This year, emphasis was placed on reflective practice (not the focus of this paper) and students found that the feedback sessions were an appropriate environment to put their developing reflective skills to use:

“I enjoyed the opportunity to reflect on my performance with the point of view of the course coordinators. They had no issue with giving direct feedback and criticism, which is often what I need.”

“Since I was required to think about something that I want to discuss in the individual feedback session, this forced me to think... so that I need to try to more reflective”

Providing students with a safe environment in which they could reflect, whilst also discussing the point of view of the course convenor and facilitator made students feel as though they could practice their reflection and improve. Additionally, as each student knew they would have a chance to ask questions in the session, this provided another incentive for pro-active and reflective behaviour.

Student satisfaction significantly increased

As previously stated, the student satisfaction in ENGN2706 had experienced a continual decline, decreasing from 82% (2012) to 78% (2013) and finally to 63% (2014). After the implementation of a flipped classroom, and additional engagement-based teaching strategies, the student satisfaction rating in ENGN2706 was 100%. This significant increase in student satisfaction demonstrates the effectiveness of implementing engagement-based teaching strategies and serves as an encouraging motivator to continually develop engineering education to increase student engagement, and hence, learning experience for future years.

Conclusion

Major changes were implemented in ENGN2706 to improve independent learning as well as student engagement. Through modifying the 'flipped classroom' approach for ENGN2706, greater flexibility in learning was provided, and independent learning attitudes were encouraged and developed in students. Pairing this independent learning with personalised feedback sessions catered for the individual nature of each students' projects, successfully engaging them with the course. These engagement-based teaching strategies have highlighted the exciting potential for utilising a flipped classroom approach in URD courses in engaging students and developing higher order thinking skills.

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