

Molding the Interactive Flipped Classroom Based on Students' Feedback

Abstract:

Flipped classroom model was widely used as an effective method to change the interaction of the students and the instructor during lectures. It allowed the students to go over the lower levels of learning in Bloom's taxonomy (knowledge and understanding) individually and at their own pace. This freed the classroom time to go over higher levels of learning, such as critical thinking, solving and analyzing problems in the classroom which helped foster deep student learning and increased retention of the topics discussed. The setting of large lecture halls discouraged students from participating in classroom activities and allowed them to be passive during lectures. It was not easy for the instructor to differentiate between students who were prepared for class or those who were not, which defeated the objective of the flipped classroom model. By adding online quizzes to the flipped classroom model, the students were encouraged and motivated to do the work as part of the course objectives before coming to class. This increased their participation in classroom activities, thus enhancing their learning experience.

In a second year fundamental engineering mechanics course, consisting of about 120 students, individually tailored pathways were designed for students to achieve the learning outcomes of the online modules. Using the graded online quizzes as an integrated part of the flipped resource material available online encouraged the students to go over the material before class. The online quizzes allowed the students multiple attempts and guided them through different resources with each unsuccessful attempt until they got the correct answer.

The author conducted an online survey on the effectiveness of the model, and was able to collect successful strategies and challenges to work on. Some of the concerns student had were: more examples in the video resources, the lack of opportunity to ask questions while watching the videos at home, the lack of people to help with the in-class problems,...etc. These were all addressed during the second time the model was used in 2016. For example, to help students with their questions while watching the videos at home, an online platform was developed for the course that allowed students to ask or answer questions anonymously. The instructor closely monitored the discussion to ensure accuracy and completeness of responses. Correct answers were endorsed by the teaching team. 82% of the students participated on the online discussion with an average response time of 33 minutes. This improved approach was received very well by the students.

This paper shares the whole experience including design, implementation, work-load, benefits and challenges of the model. The paper also discusses the changes that have been done to the model to address the students' concerns, and the students' feedback during the two rounds this model was used. The different assessment techniques used to evaluate the students' knowledge on the material covered in the flipped classroom models is discussed. A comparison between the grades of cohorts instructed with the proposed model and with the traditional model shows the benefits this model incorporated into students' learning.

Introduction:

With the advancement of the internet, the use of online modules as a form of learning has been developing fast over the past decades. Some universities go with full online courses and others go to blended learning solutions. A flipped classroom is one way that allows for blended learning. Flipped classroom models have been widely used as an effective method to change the interaction of the students and the instructor during lectures. Students learn the material at their own time and at their own pace, and come to class prepared to interact and solve problems with the instructor (R. Pierce and J. Fox , 2012; J. L. Bishop and M. A. Verleger, 2013; G. S. Mason et al., 2013; A. Butt, 2014). Some of the strengths of the flipped classroom as stated by A. Zafar, 2016, include “better retention, better conceptualization, individual student attention and application of knowledge”. The behavior and motivation of the students is an important factor in the success of the flipped classroom (S. Hsu et al, 2016; K. Bhagat et al, 2016). While the benefits are clear, there are challenges that come with it especially in large classes. The setting of large lecture halls discourages students from participating in classroom activities and allows them to be passive during lectures. It is not easy for the instructor to differentiate between students who are prepared for class or those who are not, which defeats the objective of the flipped classroom model. Using graded online quizzes encourages students to go over the material before class and holds them accountable for their learning. The online quiz allows students multiple attempts until they get the correct answer along with direct feedback. This has been proven to increase students’ retention and acts as a motivation for them to learn (M. L. Epstein et.al.,2002; R. E. Dihoff et al.,2003; J.D. Tune et al, 2013; J. Bergman and A. Sams, 2014). Another method to hold students accountable for their learning and preparation for the class in a flipped classroom design is team-based learning as proposed by OP McCubbins et al., 2014. This leads to students coming prepared to their capstone course and being engaged in the classroom. C. Liu and Z. Liu, 2016, motivated students using student led flipped classroom models (SL- FCM). Students were required to develop the online resources for sections of the English course and then lead the in-classroom activities. The use of online platforms was an essential form of communication between the students and the course instructor. This method helped increase the desire in the students to learn English and improved their independent-learning skills.

The flipped classroom model allows the students to go over the lower levels of learning in Bloom’s taxonomy (knowledge and understanding) individually. This allows the students to go at their own learning pace and will free the classroom time to go over higher levels of learning, such as critical thinking, solving and analyzing problems in the classroom.

This paper discusses the use of a flipped classroom for part of a second year required mechanics course. The class consisted on average of 120 students. The flipped classroom models used involved an interactive section to ensure student fulfillment of going over the material before coming to class and increase their engagement in the classroom. The model was implemented over two years. The paper will also talk about the lessons learned from implementing it for the

first year and what modifications were done for the second year. Finally, excerpts from the students' feedback will be presented.

Methodology:

A flipped classroom model was applied to part of a second year civil engineering core mechanics course. The course, is divided into nine basic concepts that are not equal in difficulty but are equal in importance. The course, during fall 2015, when the flipped classroom was first implemented, consisted of 2x2 hours of lecturing and 1x2 hours of tutorials per week. The course changed in fall 2016 (based on department curriculum changes) to include only 3 hours of lecturing instead of 4 and 1x2 hours of tutorial per week. Traditionally, in the course, the instructor lectured the concepts followed by problem solving on related topics. However, not all the students would participate in the problem solving part, as the problem would be related to the material lectured during the same day or week. This is due to the fact that different students learn at different paces. So some students would require more time to grasp the concepts before they could start solving problems in-class. The flipped classroom model was used to instruct the “shear stress” and “shear flow” concepts which are the topics that have the most breadth in the course. This made these topics ideal for the proposed interactive method presented below.

The learning objective of the flipped classroom was stated as follows: Using the fundamental concept of “shear stress” and its related topics, the students should be able to analyze and design structural members subjected to bending.

The instructor used “Desire to Learn” (D2L) which is the Brightspace integrated platform used by University of Waterloo (UW) to upload the online videos and references required for the concepts under discussion. To ensure that students read the online material before class; the instructor added to the course D2L a multiple choice question problem that they need to solve correctly in order to get the credit. The quiz closes two hours before class starts, so in order to get the credit, students need to solve the quiz with the correct answer at least two hours before the lecture. If students get the wrong answer while undertaking the quiz, D2L will guide them to a different path/video links that directs the students to a more thorough explanation of the concepts. The students then are directed to the quiz which is the same problem but with different numbers and the choice of the correct answer changed. If the students still get the problem wrong after the second attempt, they are directed through D2L to sub-questions of the problem to know which part of the problem the student is lacking the understanding of. This allows D2L to direct the student to the proper revision material required to understand the concept. Note that the students only get credit for the quiz if they get the right answer before class time but they are allowed unlimited trials until they get the correct answer. Figure 1 shows a flowchart that represents the procedure used in D2L.

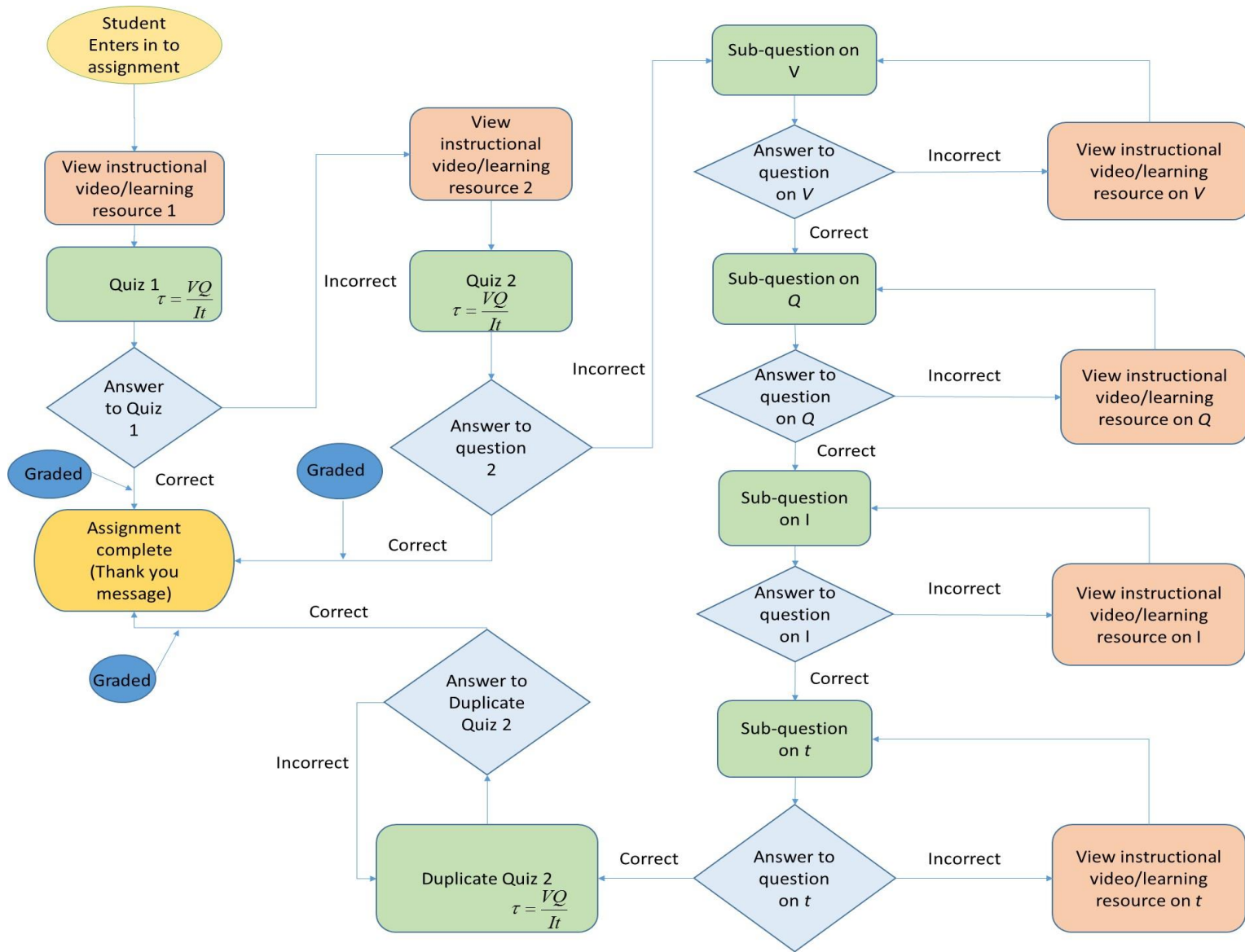


Figure 1 Flow chart showing the Interactive Online Module

During class time that follows, the instructor summarizes the concept covered through D2L and follows it by a problem session. The instructor then posts a problem on the board and asks the students to work in groups to solve it. The instructor of the course answers questions to help the students solve the problem. The instructor then goes over the concepts that the students struggled with during solving the problem with the whole class. A detailed solution of the problem is then posted on the D2L website of the course. During the last 10 minutes of the (2-hour) class time, the instructor will post a quiz question on D2L, where the students will gain half the credit for answering it during class time and half the credit for answering it correctly. They will be allowed unlimited trials after class time until they get it correct to get the credit. The students can answer the question by logging into their D2L account on their laptops, phones, etc. This helps the instructor assess the students' immediate retention by counting the number of students who got the correct answer on the first attempt. Before the final exam, another online quiz is posted for the students through D2L. This online quiz acts as a review for the final exam, where the students are asked to solve several problems relating to the different concepts covered in the course. One of the questions will be related to the concept covered through the flipped model described above while the other questions will be related to the other concepts in the course covered through the traditional method used in this course before. Again students are allowed unlimited attempts until they get the correct answer, and they only get the credit if they get the correct answer. This helps the instructor assess the retention of the students for the concept covered through the flipped model compared to the other concepts of the course by comparing the number of attempts required to get the correct answer for each question.

Assessment Techniques:

The assessment techniques used are survey questions, aggregated grade results and the online quizzes which are divided into 3 parts:

The first online quiz is done before the students come to class and it assesses the basic knowledge of the concept (lower level of understanding on Bloom's taxonomy). It also ensures that the students have the basic knowledge of the shear stress concept before coming to class and are ready to solve higher level of analysis problems related to the topics learned.

The second online quiz is done after the face-to-face meeting in-class where students have the opportunity to go over higher level of design problems. If students are able to give the correct answer from the first trial, this shows that the students have gained that higher level of analysis and design.

The third online quiz is a review quiz that is given to the students before the final exam. One of the design problems will be related to the shear stress concept (the only concept covered through the flipped classroom model), while the others will be related to different topics covered in the course, such as "deflection of beams" and "torsional deformation of members". To assess the retention of the knowledge, the amount of trials it takes the students to get the right answer in the online quiz (final exam review) is gathered. It is assumed that the students will get the right

answer from the first time, if they already knew the material and did not need to review the topic. If more revision (i.e. more quiz attempts) is required before the students get the correct answer, it is assumed that the material was not retained. A comparison of the number of attempts required to get the correct answer for the shear stress concept problem compared to the other problems will be reported to show the difference in knowledge retention for the different concepts.

In addition feedback surveys have been conducted with the students to try to understand if they thought that the flipped classroom model was helpful for their learning or not. They were also asked some open-ended questions that allowed them to convey what was the most helpful part for their learning in this model and what hindered their learning in this model.

The course was taught by the same instructor three times using the traditional method (fall 2011 (F11), F12 and F13) and two times using the flipped classroom method (fall 2015 and fall 2016). A comparison of quiz grades for all these years is being presented to try to understand if the flipped classroom method had an effect on students' performance through their grades.

In addition, the instructor of the course compared the interaction of the students to the in-class problems of the different cohorts that were taught using the traditional method (F11, F12 and F13) to the cohorts taught using the traditional method (F15 and F16)

Assessment Results:

In an effort to overcome obstacles presented by the traditional flipped classroom model, the instructor created the interactive online module, as shown on page 3, that was administered via D2L and that was available to the students through their D2L account. The problems foreseen with traditional flipped classroom models and how they were addressed through the proposed module include:

- The model relies on the preparation and trust of the students: allocating a percentage of the overall course grade when the module was completed intends to serve as a motivator for the students to complete the requirements before the class.
- Unable to track students' attempts of understanding course material: Since the online module as well as online quizzes were administered through D2L, that allowed for recording the number of attempts and scores for each students. The results were also available for the instructor for immediate viewing.
- Lack of immediate feedback to students' self-understanding: Through D2L, students were able to immediately view their scores, which allowed them to identify their misconceptions and how to correct them.
- Possibility of student getting bored from repetition or being left behind: The in-class activities were at a higher level in Bloom's taxonomy cognitive domain. Material was not repeated in the classroom, it was built upon and used for analysis of problems. However, the preparation sequence material was available for them anytime so that they can go and review it at their own time and at their own pace.

- Requires significant software and hardware resources: The module was developed using the platform that already existed at UW (D2L) which also allowed automatic grading and recording into students' grade book. A software was used to record the videos ahead of time before posting them into D2L
- There is significant work on the front end: The preparation of the video resources along with the online quizzes took a lot of time at the front end. In addition the process of how to make the restrictions on D2L for the online quizzes and the online resources took a lot of time to understand. However, the process is now documented in the department and is being used by other instructors with less time at the front end. Also the video resources can be used for future years with no problem.

In order to measure the effectiveness of the flipped classroom model, a comparison of the students getting the correct answer for the online quiz from the first attempt was compared between the first online quiz (pre-classroom), which was used to ensure that the students had learned the concepts, to the post-classroom quiz, which was used to ensure the students understood the concepts of the shear stress. In the pre-classroom online quizzes, 62 students achieved the correct answer on their first attempt. The results of the pre-classroom online shear quizzes are summarized below in Figure 2. In the post-classroom online quizzes (which were higher level problems as per Bloom's taxonomy), 106 students achieved the correct answer on their first attempt. The increase in the students who were able to solve the online quiz from the first attempt was from 52% to 90%. This was a noticeable increase that ensured that students understood the shear stress concepts after undergoing the flipped classroom model (which includes the studying before class through the model proposed followed by the interaction and problem solving session in-class).

Towards the end of the term, students were given an online survey to reflect on the effectiveness of the flipped classroom model. The survey was done in both years F15 and F16. On average the survey response rate was 42% in F15 and 75% in F16. In both years, students listed the following as the most helpful factors for their learning in the flipped classroom model:

- In-class problem solving: covering the material before class allowed them to better participate in the in class problem solving sessions.
- Learn at own pace: Having the video resources online allowed some students to learn the material at their own pace.
- Students were happy that they had the ability to rewatch the videos whenever they wanted. They considered this as an additional resource that was always available for them. They also valued that they were able to resolve the online quizzes until they got the correct answer.
- The students valued the step-by-step instructions that allowed them to figure out where their misconceptions are in the shear stress topic.

- Online quizzes motivated some students to go over the material before class as well as assess if they know the material or not.

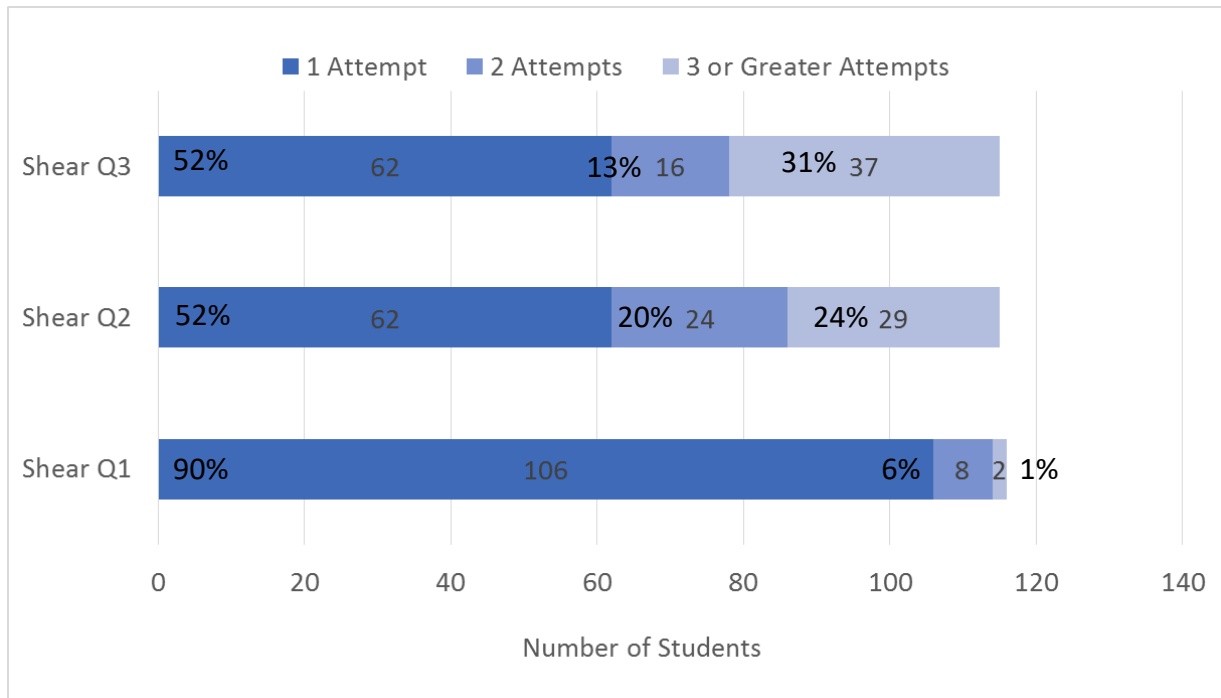


Figure 2 Students who achieved the correct answer for Shear Q1 – Q3 in F15

In F15 survey, students listed the following as factors that hindered their learning of the “shear stress” concept:

- Inability to ask questions: Students felt helpless when they were watching the videos and were unable to ask questions about misconceptions they had.
- Lack of examples and available material
- D2L confusing
- Poor video quality: More students commented on the speed of the person speaking in the video, they thought they were too fast.
- More in-class exercises: Students wanted more exercises to be covered in the classroom.
- Need more than one person available during the problem activity solving in-class.

The instructor took the time to address these concerns before implementing the flipped classroom again in F16. The concerns were addressed as follows:

- The instructor incorporated the use of an online discussion forum as part of the learning experience of the course. Students were encouraged to participate by asking questions, posting answers or follow up discussions. The teaching team (which consisted of the

instructor and the course teaching assistants) were continuously monitoring the forum to answer the questions as quickly as possible. The average response time was 45 minutes as reported by the discussion forum.

- The instructor developed more video examples related to the shear stress and shear flow concepts. The instructor also developed a handout (summary of notes) on the shear stress concept that the students could refer to in the future.
- Lots of glitches happened in D2L during the pilot implementation in F15 due to the inexperience of the instructor with the D2L website. This was worked on for F16, as a handout was developed to allow different instructors to easily upload the interactive flipped classroom model into D2L.
- In the new videos developed, it was ensured that they were recorded at a slower pace to address this concern.
- The instructor prepared more problems to solve in-class for F15.
- The instructor asked three of the course teaching assistants to be available with her during the in-class problem session.

The results from the F16 survey showed that the above problems were solved. The additional complaints student had were:

- Having to take extra time to learn the concepts outside the classroom
- Information taken down after module is over.
- Waiting 40 minutes to get an answer on the discussion forum instead of having their questions answered right away in the classroom.
- More/better video resources required.

The instructor plans on solving these problems as follows:

- Enforcing that since students are solving assigned problems in-class they are replacing that with studying the material outside the classroom time.
- Make sure to keep all the videos accessible to the students even after they complete the module.
- Monitor the online forum closely to try to shorten the response time. Recently the same forum is used in other courses and the instructor is able to keep the average response time at 15 minutes, by adding some encouragement participation grade for the students. A similar model could be used with the interactive flipped classroom discussion forum.

In addition, a comparison of Fall 2015 aggregated quiz grades that included the shear stress and shear flow concepts with 3 previous years was done (Table 1). Note F16 quiz grades were not compared, as due to the curriculum change in the department, the course was restructured and the shear stress and shear flow concepts were scattered over a couple of quizzes.

Table 1: A comparison of shear stress quiz grades across the years

	Fall 2011	Fall 2012	Fall 2013	Fall 2015
Average	88.7	86.5	82.0	81.3
Standard deviation	10.86	12.64	18.04	14.6

From Table 1 it is noted that the students' performance did not improve in F15 compared to the previous years. This is anticipated to be due to the hindering factors listed in the student survey of F15. F15 was the pilot for this study, with lots of lessons learned that were implemented in F16 and onwards. Also, the difference in cohorts could lead to some grade change as noticed in the years before. The instructor plans to change the arrangement of the course material for future years to allow for direct comparison of the above concepts with previous cohorts and avoid what happened in F16 which prevented the quiz grade comparison.

Another comparison done was in relation to the review quiz for the F15 final exam. The number of attempts until the students got the correct answer were recorded. Figure 3 shows the number of students who got the quiz question correct from their first attempt. Q5 in the figure reflects the questions related to the topics covered using the flipped classroom method while the others report questions related to other concepts covered in the course using the traditional method. Not enough conclusion can be drawn from the figure, as there was not enough difference for comparison. However, in general they still performed well with the question related to the shear stress concept.

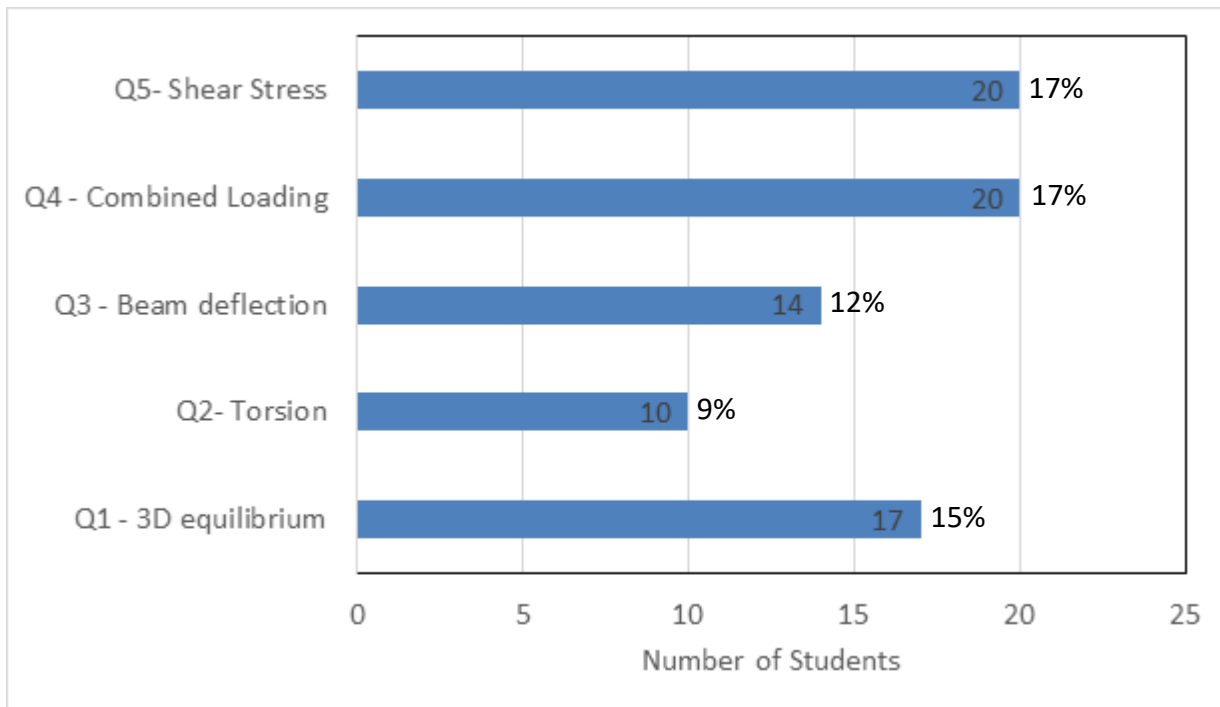


Figure 3 Students who achieved the correct answer for Q1 - Q5 in F15 in their first attempt: Q5 is Shear Formula

Another factor noted by the instructor of the course was the behavior of the students in the classroom while solving problems related to the concepts covered using the flipped classroom model, compared to other concepts in the course. The instructor reported that the participation of the students in the classroom increased from about 50% to about 90%. The instructor going around and trying to help the students solve the problems in-class noticed that they were now able to better understand how to approach the problem and needed less guidance. This allowed them to go farther along in their solution, on their own, compared to the other concepts covered in this course.

Summary

The interactive flipped classroom model proposed above and used in the mechanics course had several benefits on the students' learning experience through their second year compulsory course. It allowed them to go over the material at their own pace before coming to class. It also allowed them to understand the misconceptions they were having through the online quizzes embedded in the model. Coming to class, the students were better prepared to solve the assigned problems and interact with the course instructor. The students in general enjoyed working with the interactive flipped classroom model, however they were resisting the change and the amount of time they had to spend outside of class to prepare for the course. Several challenges were resolved based on students' feedback from implementing the pilot study and were applied the second year. The solutions included incorporating an online discussion forum as part of the course, adding video resources and handouts, more problems to be solved in the classroom and additional teaching assistants were available with the instructor during the problem sessions. This helped resolve a lot of the challenges that students faced the first time the interactive flipped classroom model was implemented. Other challenges are still available for the instructor to address in future course implementations, especially with the curriculum change in the department and the course structure change. The instructor will restructure the course for F17 to allow for future comparison of the model implementation. In addition, links to additional video resources will be provided to give the students additional opportunities to understand the concepts. It is understandable that students will continue to resist change, but with time, it is expected that other courses in the department will follow a similar model which will allow for further student acceptance.

Acknowledgements

The author would like to acknowledge the Center of Teaching Excellence (CTE) at the University of Waterloo for funding this project, Eleanor Mak (Graduate engineering student) and Talodabioluwa Abikoye (undergraduate engineering student) for their help with developing the instructional videos and online quizzes, Samar Mohamed from CTE for her guidance and support with D2L and finally Samantha Sooriyabandara (Accreditation assistant at the Civil and Environmental Engineering department at UW) for her help in creating the interactive online module template on D2L and creating the flowchart in this paper.

References

- Bergmann, Jon, and Aaron Sams. "Flipped Learning: Maximizing Face Time." T D 68.2 (2014): 28-31.
- Bhagat, Kaushal Kumar, Cheng-Nan Chang, and Chun-Yen Chang. "The Impact of the Flipped Classroom on Mathematics Concept Learning in High School." Educational Technology & Society 19.3 (2016): 134-42.
- Bishop, Jacob, and Matthew Verleger. "Testing the Flipped Classroom with Model-Eliciting Activities and Video Lectures in a Mid-Level Undergraduate Engineering Course." Frontiers in Education Conference, 2013 IEEE.
- Bloom, BS, DR Krathwohl, and BB Masia. Bloom Taxonomy of Educational Objectives. Allyn and Bacon, Boston, MA. Copyright (c) by Pearson Education.< <http://www.coun.uvic.ca/learn/program/hndouts/bloom.html>, 1984.
- Butt, Adam. "Student Views on the use of a Flipped Classroom Approach: Evidence from Australia." Business Education & Accreditation 6.1 (2014): 33-43.
- Dihoff, Roberta E., Gary M. Brosvic, and Michael L. Epstein. "The Role of Feedback during Academic Testing: The Delay Retention Effect Revisited." The Psychological Record 53.4 (2003): 533.
- Epstein, Michael L., et al. "Immediate Feedback Assessment Technique Promotes Learning and Corrects Inaccurate First Responses." The Psychological Record 52.2 (2002): 187.
- Hsu, Sheng-Der, et al. "An Investigation of the Outcomes of PGY Students' Cognition of and Persistent Behavior in Learning through the Intervention of the Flipped Classroom in Taiwan." PloS one 11.12 (2016): e0167598.
- Liu, Chengcheng, and Zhongwen Liu. "A Creative Design and Implementation of Student-Led Flipped Classroom Model in English Learning." Theory and Practice in Language Studies 6.10 (2016): 2036-43.
- Mason, Gregory S., Teodora Rutar Shuman, and Kathleen E. Cook. "Comparing the Effectiveness of an Inverted Classroom to a Traditional Classroom in an Upper-Division Engineering Course." IEEE Transactions on Education 56.4 (2013): 430-5.
- McCubbins, OP, Thomas H. Paulsen, and Ryan G. Anderson. "Student Perceptions Concerning their Experience in a Flipped Undergraduate Capstone Course." Journal of Agricultural Education 57.3 (2014): 70-86.
- Pierce, Richard, and Jeremy Fox. "Vodcasts and Active-Learning Exercises in a "flipped Classroom" Model of a Renal Pharmacotherapy Module." American Journal of Pharmaceutical Education 76.10 (2012): 196.

Tune, J. D., M. Sturek, and D. P. Basile. "Flipped Classroom Model Improves Graduate Student Performance in Cardiovascular, Respiratory, and Renal Physiology." Advances in Physiology Education 37.4 (2013): 316-20.

Zafar, Afsheen. "Flipped Class-Making that One Hour Effective in a Resource Constrained Setting." Journal of the College of Physicians and Surgeons Pakistan 26.9 (2016): 795-7.