A Flipped-Classroom Format Applied to a Software-Based Course

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Abstract

The Citadel's Mechanical Engineering program offers a course that utilizes the SolidWorks software program as a means to introduce students to Computer-Aided Drafting and Finite Element Analysis. Early offerings of the course focused on learning how to use SolidWorks in a combined lecture and lab format. The instructor passed on their knowledge to the students by lecturing concepts and through demonstration. This session, which typically required 30-45 minutes, was followed by a hands-on session where the instructor could easily move around the classroom and help as students worked on exercises related to the day's material. With small numbers of students in early course offerings, the instructors did not assign a textbook, but relied on notes and handouts. A textbook was implemented in a later offering of the course, while the instructor used the same approach in the classroom. As the engineering program grew, the instructors sought alternative classroom management techniques while maintaining a high-level of student-instructor interaction. As such, the pedagogical approach has shifted the instruction of the software out of the classroom in order to maximize the time for individual student interaction. In the current format of the course, the instructor assigns a series of short instructional video lessons provided by SolidProfessor to be watched before coming to class. During classroom time the instructor provides a short overview and discussion, for approximately 10 minutes, and then allows the students to work on the daily assignment. Initial findings of the students' perception on this new teaching style were found to be inconclusive. While a section of the students appreciated the approach, some students complained about the tiresome videos and lack of immediate practice. With student numbers increasing from 3-10 students in one to two sections, to 13-24 students per section with 6 sections, the value of the flipped-classroom format is being reinvestigated for this software-based course. This paper summarizes the results of previous investigations and adds new data from revised and more detailed surveys and through feedback from faculty.

Keywords

Flipped Classroom, Software Course, Online Assignments

Flipped-Classroom

Early research shows that primary learning might take place individually through a medium such as the internet, thus liberating classroom time for experiential activities. The internet appears to have the flexibility needed to let students choose the material order and presentation format that best suit their own preference[1]. A flipped or inverted classroom is a method that can free classroom time for learner-centered activities[2]. In a flipped classroom (FC), course content is disseminated outside the classroom through media such as video lectures and web-based tutorials, in addition to traditional methods such as assigned reading, assigned homework

problems, interactive exercises, and power-point presentations. Students are responsible for learning basic course material outside of class time. Unlike an online class, an FC includes face-to-face time with the instructor in a classroom or laboratory setting where the material learned outside of class is discussed and applied. The FC allows an educator to present course material in several different formats, and so engages the different learning styles and preferences of students. The FC format encourages students to become self-learners and help prepare them for how they will need to learn as practicing engineers.

One of the great advantages of the FC is that the supplemental materials such as videos, illustrative problem solving, and application examples may stay available to students during the entire semester or even longer[3], providing a source of reference material and encouraging self-directed learning. In addition, the more interactive class time in a FC provides more opportunity for students to interact with their peers and increases student cohesiveness. Students in a flipped classroom may be more autonomous, leading to higher self-efficacy. There is also a confirmation that a flipped classroom will increase active learning[4].

Computer Applications Course at The Citadel

MECH 325 Computer Applications is a course taught in the Mechanical Engineering Department at The Citadel and covers topics such as Computer Aided Design (CAD) and numerical methods. Initially it was offered as a junior-level course, but starting this year the curriculum was adapted to offer the course primarily to sophomores. The Mechanical Engineering faculty, from the very beginning, investigated alternative approaches to instruct, mostly motivated by increasing enrollments, keeping current on an evolving software program environment, and fostering classroom discussion. They had the goals to increase student-instructor interaction, promote critical thinking, and improve the overall student learning experience. The department chose SolidWorks as the CAD software for course and obtained an extended (multi-year) license.

Initially, student enrollment in the course was small (fewer than 10), but has since grown into full computer labs of 24 students. The instructors in the early offerings of the course lectured on using the software and spent approximately half of the classroom time assisting students as they worked on examples in class. Students received all instruction in the lab and from information posted on Blackboard. The three initial offerings of the course did not require a textbook. However, during the fourth offering, the instructor required a textbook and assigned work to prepare students for the class and lab. Instructors up to this point had relatively small sections and could interact with all students. With the growth of the program and student enrollments, the fifth offering of this course posed a challenge to continue with either of the two previous styles. While the SolidWorks software is important for preparing students for work or graduate school, it required significant classroom time and resources to lecture, which competed with class time for hands-on work. The faculty chose to teach the course using a hybrid approach and assigned an “e-text” (SolidProfessor) for the course.

SolidProfessor for SolidWorks

SolidProfessor provides an on-line learning resource for teams, schools, and individuals to keep up with rapidly evolving engineering tools and technologies. Ongoing learning is essential to staying current with the latest SolidWorks capabilities. SolidProfessor's concise, self-paced

video lessons, hands-on exercises, and assessments help students learn and improve engineering skills. On top of that, SolidProfessor memberships include access to courses in dozens of topics and titles including Principles of FEA, 3D Printing, Matlab, Mastercam, CAMWorks, and much more[5].

The SolidProfessor content is very flexible and the FC was developed to target and mirror the learning objectives in the traditional classroom. As such, students were assigned groups of videos and tests to complete before coming to class. The SolidProfessor software management system allows the instructor to know if, when, and how much of the assigned video each student has played/watched. On the day of the class, a brief overview of the topics covered was conducted and the rest of the time was devoted to working with the SolidWorks software.

Survey of Student Perception

After a first semester of the FC model, survey data was collected and revealed positive student impressions about the flipped learning method. The instructor was able to spend more time with each student answering questions. Previously, a significant portion of the class and lab was devoted to instructor lectures on how to use the software. This change in instruction where much of the 'how to' part is the student's responsibility has allowed more time in-class for discussion and hand-on exercises. However, many students complained about how monotonous and tiresome some instructional videos were and some openly admitted to not watching them. This semester, due to even bigger enrollment related to mixed sophomore and junior population, the instructors decided to closely investigate the students' commitment to the on-line assignments and their influence on homework and test grades. One hundred and eighteen students participated in a survey distributed shortly after first test.

Fourteen statements were evaluated using a 5-point Likert scale with 1 being 'Strongly Disagree' and 5 being 'Strongly Agree'. The statements and average responses are listed in Table 1.

Based on the results it can be seen that students prefer hands-on experience and that spending class time on exercises makes them feel prepared for homework and tests. Most of them prepared for the tests by practicing drawing in SolidWorks rather than watching/re-watching the instructional videos in SolidProfessor. However, the students still lean towards learning by attending a lecture delivered by your instructor (11% disagreed, 40% were neutral and 49% agreed that they preferred to learn from an instructor). Considering that this course format pairs the slightly less popular option of watching lecture videos outside of class with the much preferred learning method of completing in-class examples, the net result is likely a positive one.

The survey statements were followed with four yes/no questions. Answer 'yes' was represented by value 1 and answer 'no' was represented by 0 in calculations. These questions and average responses are listed in Table 2.

The survey results show that 95% of students purchased SolidProfessor account and watched videos and that 90% watched the videos on time. The results of the last questions show again that the students felt prepared for the test and that they would not study differently.

Table 1. MECH 325 students' responses evaluated using a 5-point Likert scale

		Results (with standard deviation)
1	I enjoy the 'flipped classroom' model (watching videos outside of class and doing practice problems in the classroom) in MECH 325	3.21 ± 1.27
2	I prefer to learn by attending a lecture delivered by your instructor	3.53 ± 0.93
3	I prefer to learn 'hands-on' by doing examples	4.62 ± 0.52
4	I feel prepared to do examples in class	3.79 ± 1.07
5	I think the in-class examples are easy	3.22 ± 0.86
6	I think SolidProfessor videos help you prepare for class	3.30 ± 1.18
7	I think SolidProfessor videos help you prepare for examples used in class	3.31 ± 1.10
8	I think the homework is easy	3.22 ± 0.93
9	I feel like the SolidProfessor videos prepare you to complete the homework	3.30 ± 1.08
10	I feel like the in-class examples prepare you to complete the homework	4.21 ± 0.75
11	I thought the test was easy	3.60 ± 0.99
12	I felt prepared for the test	4.03 ± 0.96
13	I prepared for the test by watching/re-watching SolidProfessor videos	2.64 ± 1.20
14	I prepared for the test by drawing in SolidWorks	3.39 ± 1.27

Table 2. MECH 325 students' yes/no responses (yes - 1, no - 0)

		Results (with standard deviation)
15	Do you have an account with SolidProfessor? If not, please state the reason why you did not purchase the access to SolidProfessor.	0.96 ± 0.21
16	Do you watch the assigned SolidProfessor videos? If not, please state the reason why you do not watch assigned videos.	0.96 ± 0.21
17	Do you watch SolidProfessor videos before due dates? If not, please state the reason why you are late with assigned videos and if/when you catch up.	0.89 ± 0.31
18	Will you prepare for next test differently? If yes, what will you do to prepare better?	0.32 ± 0.47

However, some students did not purchase the SolidProfessor account and did not enjoy watching the videos. Some of the comments collected are listed below:

- Money is tight and I have yet to feel comfortable purchasing the access.
- [Videos] are painfully boring.

- Sometimes I forget and [videos] require more attention than most HWs.
- Have not had time to watch hour long videos during my study hours. I catch up on weekends if I can.
- I can't learn watching videos while not being able to follow along doing the examples.
- I watch [videos], but I don't learn that way. I'm too ADHD to sit for 40 minutes without the program actually in front of me.

The survey was concluded with two more questions. The questions and average responses are listed in Table 3.

Table 3. MECH 325 students' responses to closing questions

		Results (with standard deviation) [min]
19	On average, how long does it usually take you to complete each in-class example?	26.6 ± 17.8
20	On average, how long does it usually take you to complete each homework problem?	30.2 ± 24.0

The survey shows that students spent practice time that was planned and expected by the instructors.

SolidProfessor Scores vs. Course Grades

As the semester progressed, more students failed to use SolidProfessor, and the course instructors analyzed the correlation between SolidProfessor scores and homework and test grades. SolidProfessor offers various methods for assessing students' progress and in the case of MECH 325 a Review Test was required to be taken after watching the instructional videos.

The SolidProfessor 'lessons' are assigned once a week and the Review Test must be taken before the first lecture of the week for full score. In case a student is late, penalty points are taken off the score. The Review Test can be retaken once and the best score is recorded as part of the final course grade. Table 4 presents a table of the bivariate correlation values between SolidProfessor review test grades, Homework grades, Test 1, and Test 2, and each of these correlations is statistically significant. To display these effects in more detail, Figure 1 plots course homework and test averages against 5-point ranges of SolidProfessor Review Test scores.

Table 4. Bivariate Correlations between student grades

	1	2	3	4
1. SolidProfessor	—	.526**	.258*	.288**
2. Homework		—	.512**	.619**
3. Test 1			—	.511**
4. Test 2				—

*Note: *p<.05, **p<.01*

It can be concluded that there is a close correlation between SolidProfessor practice and course performance. Low SolidProfessor Review Test scores may be explained by not watching or not paying attention to the videos or being late with both watching videos and taking review tests. While causality cannot be determined from the correlations shown in Table 4, often students who did not complete SolidProfessor assignments on time also did not do homework on time, leading to poor scores in both areas. From these results, SolidProfessor scores are most strongly associated with homework grades. Because SolidProfessor provides a good portion of the lecture content of the course, poor performance on those review tests indicates that students do not comprehend the lecture material and are unlikely to perform well on the homework, which assesses their ability to apply that knowledge. Test scores are not affected as much as taking tests is mandatory and happens during class time so late submissions are not an issue. The relationship between homework scores and test scores, however, is very strong, potentially because of the similar format of homework and test problems, which both ask students to correctly model a part given a dimensioned engineering drawing.

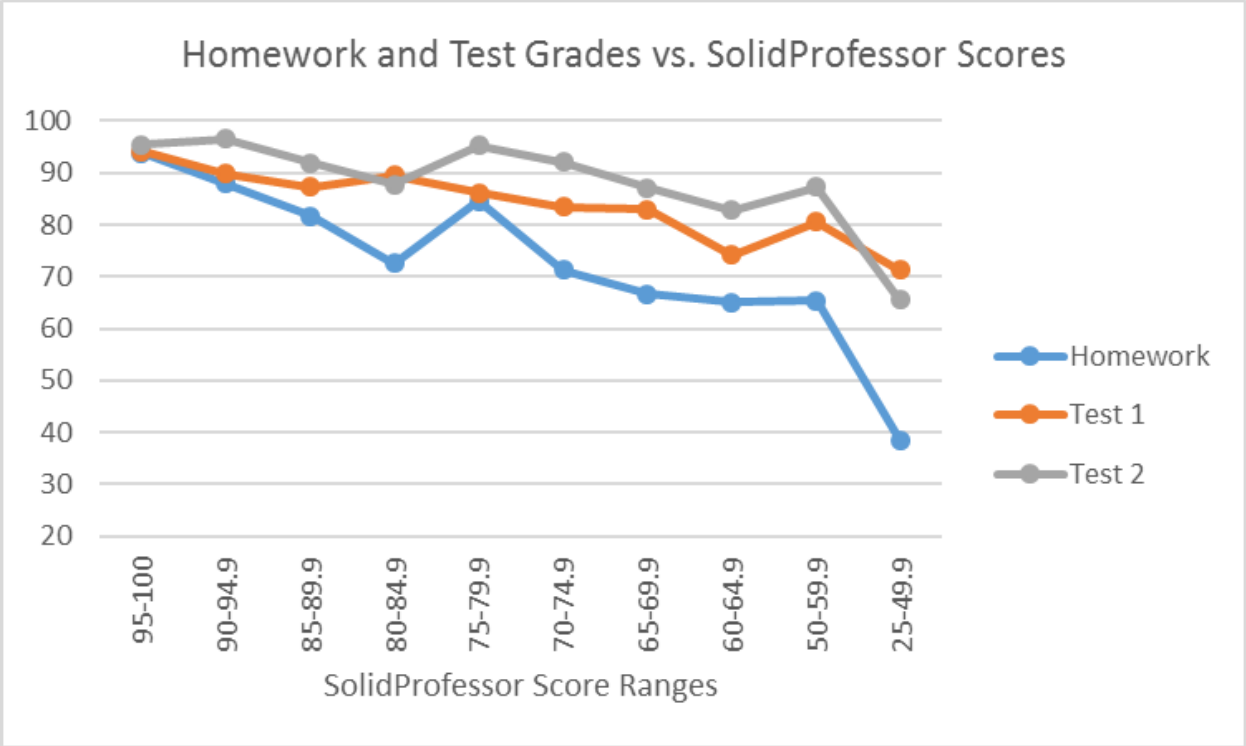

Figure 1. Correlation between homework and test grades and SolidProfessor Review Test scores

Conclusions

SolidProfessor and the flipped classroom model of instruction proved to be worth implementing into the curriculum; however, the problem of students not preparing for class remains the main issue. Those that struggle to prepare ahead of time tend to perform worse on homework assignments and tests. Because the primary feature of this instructional style is shifting lecture material into pre-class preparation, this method tends to hurt those that fail to complete their assignments on time. In the future offerings the instructors will concentrate on encouraging

students to take a better advantage of the available on-line resources and emphasizing the need to watch lecture videos before class.

References

1 Wallace, D.R., Mutooni, P., 'A Comparative Evaluation of World Wide Web-Based and Classroom teaching,' Journal of Engineering Education, July 1997, p. 211-219

2 Mason, G. et al., 'Inverting (Flipping) Classrooms – Advantages and Challenges,' ASEE Annual Conference and Exposition, 2013

3 Bachnak, R., Maldonado, S.C., 'A Flipped Classroom Experience: Approach and Lesson Learned,' ASEE Annual Conference and Exposition, 2014

4 Butler Velegol, S., Zappe, S.E., 'How does a Flipped Classroom Impact Classroom Climate,' ASEE Annual Conference and Exposition, 2016

5 SolidProfessor: Self-Paced SOLIDWORKS® Courseware, Retrieved from http://www.solidworks.com/sw/products/details.htm?productID=563 on 11/19/2017

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