MORE TIME FOR HANDS-ON LEARNING: FLIPPING THE ENGINEERING CLASSROOM IN A POLYTECHNIC

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Abstract - This case study examines the use of the flipped classroom model in the polytechnic environment. This research gathered data through four student surveys and student grades and supported by overall instructor reflections. Overall this research indicates that using the flipped model in an engineering polytechnic education environment can be successful in extending in-class hands-on learning time while maintaining high levels of student satisfaction and grades.

Keywords: flipped classroom, polytechnic, surveying, civil engineering technology, student success, hands-on learning

1. INTRODUCTION

In polytechnic education, “Hands-on, experiential learning opportunities are integral to the curriculum, providing students with practical training for jobs in demand” (Polytechnics Canada). The goals of a polytechnic closely aligns with the goals of a flipped classroom. Classroom lectures are replaced by out of class theory learning and in-class guided practice; “The time gained by removing the lecture portion from class allows for more one-on-one personal engagement” [10].

Higher education classrooms benefit from using active learning as an engaging teaching practice [2]. “...during active learning, students may be prone to misconceptions and frustration as they develop ideas without direct instruction and require support and scaffolding in order to obtain the deeper understanding promised by this technique.” [13] The flipped classroom model attempts to mitigate this by using all of the valuable class time for active learning and out of class time for theory learning.

A flipped classroom relies on prepared material being delivered ahead of the scheduled face-to-face class time, so the classroom time can be dedicated to applying the learning in a hands-on way [8]. The majority of research into the flipped classroom model has focused on kindergarten to 12 education [4, 5] or university education, [1,6,9]. In a polytechnic engineering environment, this

results in more time dedicated to hands-on learning under the guidance of the instructor.

This case study will compare the experience of two cohorts: one flipped model cohort (FMC) and one traditional model cohort (TMC). Student experiences will be analyzed through a comparison of satisfaction with hands-on time, reported overall satisfaction with the course and instruction, and grades.

2. CLASSROOM MODELS

“In a traditional teaching model, the instructor facilitates content attainment through various means in a classroom setting. Students are then given the responsibility of applying the concepts, generally in the form of homework assignments. In a flipped model, the roles are reversed, with students being responsible for attaining the content before coming to class, at which time the instructor facilitates the application process.” [7].

The Estes, Ingram and Liu (2014) model of the flipped classroom breaks down the process into three straightforward stages:

- Pre-class work,
- In-class work, and
- Post-class work.

In the traditional classroom model, a student’s time outside of class is devoted to post-work (homework, practice, reading, etc.); in the flipped classroom model, this time outside of class is allocated to pre-work. “Much of the success of the flipped approach depends on the interplay between pre-class and in-class activities.” [11]. Pre-class the student watches a video or does an activity which leads directly to the in-class work. It is this hands-on skilled based work that can be guided by the instructor inside of the class therefore focusing on theory learning for pre-class work. This pre-class work is prepared by the instructor but does not necessarily require the supervision of the instructor in the way that measuring angles using a total station would.

3. METHOD

This case study compares two cohorts of a level one course in the Civil Engineering Technology program at a Canadian Polytechnic. The course introduces basic surveying principles related to the measurement of distances, angles, and positions on the ground. Students perform measurements in the field using surveying tools and equipment. There is emphasis on field note format, field work preparation, and leadership and teamwork. The course is 75 hours and 3 credits. It is delivered as one consecutive 5 hour block per week for 15 weeks. This course entails the learning of new theory, which can include mathematical calculations, as well as practical hands-on use of surveying equipment. The student needs to combine both of these to perform a successful survey.

The primary researcher (the instructor) and the secondary researcher worked in tandem throughout the term in alignment with ethical requirements set out by the Polytechnic's Research Ethics Board. The instructor for the course prepared the videos for the FMC and the lesson plans for both cohorts.

The secondary researcher performed the surveys with the students with the instructor removed from the room, and kept the data secure during the term. Students were surveyed three times in the year; the first week of class, before midterms, and on the day of the final exams. Student data was anonymized by the secondary researcher so the instructor did not know who was participating in the research and grades were not accessed for research purposes until after the submission of final grades.

The surveys gathered data focusing on these characteristics:

- Quality and usefulness of posted material and resources (only for flipped cohort)
- Quality of instruction
- Time available to work on skills with equipment in class
- Overall satisfaction with the course

Data was gathered from the Learning Management System (LMS) for each cohort and focused on:

- Formative assessments – weekly written and field assignments
- Summative assessments – exams
- Final course grades were gathered and analyzed through the LMS (after final grades had been submitted)

The instructor also reflected in a journal after each class to support the data gathered.

3.1 Participants

Participants were 60 students enrolled in a first year Civil Engineering Technology course divided into two cohorts that were assigned by student choice (based on schedule) or assigned by scheduling (based on enrollment). Neither group was aware when they registered that the two cohorts were following a flipped or traditional classroom model. Twelve students from each cohort consistently participated in the survey gathering.

3.2 Procedure

Fig. 1. Traditional model cohort (adapted from [3]).

Fig. 2. Flipped model cohort (adapted from [3]).

In the traditional classroom method (TMC) of delivery, students attend class for the 5 hour block. For the first 2 hours, there is a lecture portion, with examples and practice calculations or theory. Then the students sign out equipment, and go into the field to perform a surveying measurement exercise. They would have the 2-3 hours to perform the survey, and gather all the notes. Any math or analysis that needed to be completed would then go home for post-class work.

In the flipped classroom (FMC), students are given access to lecture capture videos online as pre-work. These videos give an overview of the topic, the lecture material, and sample calculations. When students attend class in the 5 hour block, it begins with a follow up activity to check their understanding of the videos. There is no re-teaching of the concepts presented in the videos. The students then get 4-5 hours to work with equipment, and complete the math and analysis required. This is all hands-on guided practice and skills building time.

4. RESULTS

Student survey data was examined for emergent themes. Reported level of satisfaction, and grades were compared. Instructor reflections were reviewed to add context.

4.1. Student Hands-On Practice

The students in the TMC had 1-2 hours less per week of hands-on practice with the surveying equipment. However, there is little difference in reported satisfaction with the amount of hands-on time given. Students from both cohorts consistently reported highest levels of satisfaction.

Students reported satisfaction using a Likert scale as follows: Least satisfied (1), Could be better (2), Moderately satisfied (3), Good level of satisfaction (4), and Highest level of satisfaction (5).

Fig. 3. Satisfaction with hands-on time.

4.3 Student Satisfaction

Student satisfaction includes combined ratings on overall satisfaction with the course and satisfaction with quality of instruction. Students from both cohorts consistently reported highest levels of satisfaction.

For example, there were similar comments from both classes when asked about student satisfaction: "Excellent teacher" (FMC) and "Great instructor" (TMC).

Students reported general positivity in the course, again with similar comments in both cohorts: "It's a good course" (FMC) and "all good" (TMC).

Each cohort felt that the model that was used in their cohort was the preferred model: "Keep doing it this way for next semesters Wednesday class" (FMC) and "Great work, very easy to succeed in this class" (TMC).

Using the same Likert scale, satisfaction levels were reported as follows: Least satisfied (1), Could be better (2), Moderately satisfied (3), Good level of satisfaction (4), and Highest level of satisfaction (5).

Fig. 4. Student satisfaction.

4.4 Grades

The final course grade is comprised of 20% for weekly field work and assignments and 80% for assessments. The assessments are four exams worth 20% each; midterm theory written, midterm field practical, final theory written, and final field practical.

Grades reported are for the entire cohort using the LMS.

The researchers anticipated a difference in grades between the cohorts. Figure 5 shows that both groups performed similarly on all four assessments.

Fig. 5. Assessment grades.

Honours standing at this Polytechnic is at 80%, (which is an A- or a 3.5). Using this benchmark for the final course grade, as shown in Fig. 6, both cohorts performed similarly.

Fig. 6. Final course grades above 80%.

5. DISCUSSION

“Flipped learning is not about how to use videos in lessons. It's about how to best use in-class time with students.” [12]. Students do not report greater satisfaction in either model, nor do the grades reveal a more than a slight difference. It would be difficult to attribute this slight difference to the flipped classroom model, or increased hands-on time. Students report satisfaction with the teaching model as long as the instructor uses engaging teaching techniques. As both cohorts had an engaging experience through hands-on active learning (with surveying equipment), these findings align with Jensen, Kummer and Godoy's [7] conclusion that the use of the use of active learning (in either a traditional model or flipped classroom) is more engaging to students than the use of direct instruction techniques.

Larger questions remain about knowledge and skills retention of flipped classrooms. It is this skills practice which is of particular interest in the polytechnic engineering classroom. Even though students in the TMC had 1-2 hours less hands-on practice with the surveying equipment than the FMC, the majority of students in both cohorts reported high levels of satisfaction with the amount of time given. There are established methods for teaching theories, active learning for example, but the exploration of skills-based learning and increased practice time has implications for all higher education engineering classes. In this case study, students have an increase of time (1 to 2 hours a week over 15 weeks) allocated to hands-on learning; what are the long term effects of this increased time? There are further questions about the effect of increased hands-on time on job performance and long term retention of information. Students have greater exposure to equipment with a skilled instructor; the effects might not be evident in one course in one term. The greater effect may have yet to be uncovered.

Students report being satisfied with the amount of hands-on time, so the questions must be asked about why an instructor in an engineering class would chose this model. More research is required in this area – if hands-on learning is a goal of polytechnic education then increasing the time allocated to this type of learning could further this goal.

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References

- [1] Lakmal Abeysekera and Philip Dawson, "Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research", *Higher Education Research and Development*, vol. 34, no. 1, pp. 1-14, August 2014. Available as of August 14, 2014 from <http://dx.doi.org/10.1080/07294360.2014.934336>
- [2] Arthur W. Chickering and Zelda F. Gamson. "Seven principles for good practice in undergraduate education." *AAHE bulletin*, vol. 3, pp. 3-7. March 1987.
- [3] Michele D Estes, Rich Ingram, and Juhong C. Liu. "A review of flipped classroom research, practice, and technologies.", *International HETL Review*, vol. 4, no. 7, pp. 1-8, July 2014.
- [4] Kathleen Fulton, "Upside down and inside out: Flip your classroom to improve student learning", *Learning & Leading with Technology*, vol. 39, no. 8, pp. 12-17, April 2012.
- [5] Clyde Freeman Herreid and Nancy A. Schiller, "Case studies and the flipped classroom" *Journal of College Science Teaching*, vol. 42, no. 5, pp. 62-66, May 2013.
- [6] Susan L. Hotle and Laurie A. Garrow, "Effects of the traditional and flipped classrooms on undergraduate student opinions and success", *Journal of Professional Issues in Engineering Education and Practice*, vol. 142, no. 1, pp. p.05015005, August 2015. Available as of January 2016 from [https://ascelibrary.org/doi/abs/10.1061/\(ASCE\)EL1943-5541.0000259](https://ascelibrary.org/doi/abs/10.1061/(ASCE)EL1943-5541.0000259)
- [7] Jamie L. Jensen, Tyler A. Kummer and Patricia D.D. M Godoy, "Improvements from a flipped classroom may simply be the fruits of active learning", *CBE-Life Sciences Education*, vol. 14, no. 1, ar5, March 2015. Available as of March 2015 from <http://www.lifescied.org/content/14/1/ar5.full>
- [8] Maureen J. Lange and Glenn Platt, "The Internet and the Inverted Classroom," *The Journal of Economic Education*, vol. 31. no. 1, pp. 30-43, ar5, January 2000. Available as of March 2010 from <http://www.tandfonline.com/doi/citedby/10.1080/00220480.009596756?scroll=top&needAccess=true>
- [9] Sarah McLean, Stephanie M. Attardi, Lisa Faden, and Mark Goldszmidt, "Flipped classrooms and student learning: not just surface gains." *Advances in physiology education*, vol.40, no. 1, pp. 47-55, March 2016.
- [10] Amy Roehl, Linga Reddy Shweta, and Gayla Jett Shannon. "The flipped classroom: An opportunity to engage millennial students through active learning", *Journal of Family and Consumer Sciences*, vol. 105, no. 2, pp. 44-50, April 2013. Available as of April 2013 from <http://web.b.ebscohost.com.libezproxy.nait.ca/ehost/pdfviewer/pdfviewer?sid=694c58b6-f390-44d5-8214-340f78eec833%40sessionmgr103&vid=1&hid=129>
- [11] Cristina Rotellar and Jeff Cain. "Research, perspectives, and recommendations on implementing the flipped classroom", *American journal of pharmaceutical education*, vol. 80, no. 2, pp. 34, March 2016. Available from March 2016 from <http://www.ajpe.org/doi/10.5688/ajpe80234>
- [12] Aaron Sams and Jonathan Bergmann. "Flip your students' learning", *Educational leadership*, vol. 70, no. 6, pp 16-20, March 2013.
- [13] Nicholas H. Wasserman, Christa Quint, Scott A. Norris, and Thomas Carr. "Exploring flipped classroom instruction in Calculus III." *International Journal of Science and Mathematics Education*. Vol 15, no. 3. Pp. 545-568, March 2017.