

Breaking Ground: Improving Undergraduate Engineering Projects through Flipped Teaching of Research Techniques

Tasha Maddison

Science Liaison Librarian

Engineering Library, University of Saskatchewan

tmd133@mail.usask.ca

Donna Beneteau

Sessional Instructor, Drill/Blast/Excavate

Department of Civil and Geological Engineering, University of Saskatchewan

dlb548@mail.usask.ca

Brandy Sokoloski

Summer Research Assistant (and Drill/Blast/Excavate Student)

Department of Civil and Geological Engineering, University of Saskatchewan

bls533@mail.usask.ca

Abstract

This paper describes the use of flipped teaching for information literacy instruction in a new course, Drill, Blast, and Excavate, within the mining option for geological engineering (GeoE) students. These students will enter the mining industry with less discipline specific knowledge than a student that graduated with a degree in mining engineering, yet on the job training provided by the employer will fill in most of the technical gaps. With the internet connectivity readily accessible, engineers in the workplace do not need to rely solely on co-workers, short courses and conferences for upgrading their knowledge. With this in mind, we developed a flipped teaching assignment to teach students how to effectively and efficiently access electronic information. The course included a research project that allowed the students to practice these information retrieval and evaluation techniques, so as to better prepare them for the working world. These students were very engaged in learning and applied these techniques successfully in their written report and oral presentation.

Keywords: flipped teaching, mining, geological engineering, library instruction, research assignment, active learning techniques, student engagement

Introduction

The concept of flipped teaching is not unique, as many undergraduate English majors are familiar with in-depth literature studies that rely on them having read the text in advance. While it could be argued that humanities and social sciences have been utilizing the flipped teaching methodology for many years (Berrett, 2012, para. 16) it is the addition of video captures of lecture content and the inclusion of active learning principles in-class, which really define flipped teaching. Flipped teaching is generally described as the “inver[sion] of the traditional lecture-plus-homework formula. By moving the delivery of foundational principles to digital media ... class time is freed up for engaging activities that allow students to apply these basics to practical scenarios in the presence of their instructor” (Arnold-Garza, 2014, pg. 10). The flipped teaching approach is typically most successful when the instructor is already well versed in adding active learning techniques into classroom activities in which all students are encouraged to apply their learning.

The application of this methodology in the Drill, Blast and Excavate course (GeoE 498) was grounded in the instructor’s desire to increase her ability searching for relevant materials on-line. She felt uncertain about her library research skills, even though she had already completed a Master’s degree in Engineering and had attended previous presentations from the library on how to retrieve material. The instructor’s goal was to challenge her students and the librarian with a hands-on activity that she personally found arduous, to see if they might demonstrate new search techniques that she had not discovered yet.

According to Musser (2007) regarding the research practices of mining engineers, “journal articles remain the most heavily used format, followed by conference papers, books, technical reports, dissertations/theses, and other materials – the same order of importance as engineering as a whole” (para. 6). It is therefore critical to teach undergraduate students the value of published literature not only so that they can efficiently retrieve relevant information, but also so that they are encouraged to publish valuable case studies whether they end up working in industry or pursuing an academic career.

Literature Review

It was possible to conduct a comprehensive literature review of the library research, as there is very limited coverage of this technique with regards to library instruction in higher education at the moment. Indeed a survey of library databases reveal limited resources on the topic. Searches were conducted using only the term ‘flipped’ to

broaden the scope as much as possible and the results were filtered for academic and/or library applications.

Roehl, Reddy and Shannon (2013) expand Arnold-Garza's definition of flipped teaching by acknowledging the use of "class time for active learning versus lecture provides opportunities for greater teacher-to-student mentorship, peer-to-peer collaboration and cross-disciplinary engagement" (pg. 44). The authors go on to suggest that flipped teaching is most successful in "courses in which a lecture is primarily based on disseminating information and learning occurs when students apply these instructions to complete a task or an assignment" (Roehl, Reddy and Shannon, 2013, pg. 46). Strong parallels can be drawn from the author's research to information literacy instruction in libraries that provides students with foundational research principles and then asks students to apply those skills by searching, retrieving, evaluating, synthesizing and summarizing the research literature. Roehl, Reddy and Shannon further suggest that "teachers must include clear expectations of self-direction" (2013, pg. 48), a point which is echoed by Ebbeler. The concept of flipped teaching needs to be introduced to students and the instructor will need to spend "time training students in how to take such a class, and in what their role in a flipped class will be (and what yours is)" (Ebbeler, 2013, para. 7). Ebbeler (2013) also raises some interesting points regarding students and their expectations of the classroom setting as "[she] soon discovered ... that nobody told the students they were supposed to hate lectures. They were genuinely disoriented when [she] didn't spend class time lecturing" (para. 5).

Arnold-Garza (2014) and her colleagues at Towson University endeavoured to understand the effectiveness of providing information literacy instruction utilizing a flipped teaching methodology through a pilot project that assessed 14 sessions delivered by 7 librarians. The homework given to students in advance of the library instruction were repurposed tutorials that had previously been available through the library's help guides. In addition to the video tutorials, "each assignment included a quiz or other task ... provided an opportunity for students to reflect on their own understanding of the materials, and gave librarians an idea of the number of students who completed the assignment" (Arnold-Garza, 2014, pg. 11). The in-class session began with a brief review of the materials followed by structured or unstructured activities based on a specific assignment, where "librarians guided students through active learning exercises that required them to apply the concepts introduced by the pre-library session assignment" (Arnold-Garza, 2014, pg. 11). Assessment for this pilot project was conducted through a post-instruction questionnaire as well as group interviews "conducted by librarians ... to gather more detailed feedback about their observations" (Arnold-Garza, 2014, pg. 11). Although the librarians struggled to determine the level of engagement of students and their understanding of the

materials; the professors felt very positively about the overall outcome of the library instruction session as noted in their personal comments (Arnold-Garza, 2014, pgs. 12-13).

Datig and Ruswick (2013) offer many practical suggestions for the implementation of flipped teaching methodology into information literacy instruction through four separate librarian led activities: searching databases, keyword searching, web site evaluation and identifying source types (pgs. 250-251). A key factor in successful flips is developing a strong partnership with the faculty member as this technique relies heavily on the willingness of students to review the course content outside of class time. The faculty member can reinforce the importance of watching the video content in advance and then recommend that students enter the class prepared to work on a graded assignment or some other form of assessment directly tied to the curriculum. The collaboration between the librarian and the faculty member ensures that the assignment and/or assessment are relevant and appropriate for this particular group of student; so much the better if they create the assignment together. This approach “requires the librarian to relinquish control and authority over the classroom” (Datig and Ruswick, 2013, pg. 257), thus relying on the confidence of the librarian with the materials when participating in student-led learning as the agenda may not always go according to plan.

Methodology

The students were provided with an instructional video on advanced research techniques that was prepared by the librarian, and an assignment sheet that the instructor created that corresponded with the video content. **Assignment 1A** (Appendix A) was expected to be handed in prior to a hands-on tutorial in the library that occurred several days later. The overall assignment involved four steps, as outlined below:

Homework:

1. Watch the video at home, on researching a topic related to the course. Mine “slimes” from underground was the topic chosen for demonstrating research techniques in the 14 minute video, as it is difficult to find relevant information on this topic.
2. Answer **Assignment** sheet **1A** prior to the next class. The questions included were:
 - a. What is the address of the on-line search engine at the university?
 - b. What item was searched in the video?

- c. Provide examples of limiters for refining search items.
- d. How do you search for groupings of words?
- e. What does it mean when a title is highlighted in blue?
- f. What is a bibliographic database?
- g. List a technique to exclude results from search items.
- h. List a technique to retrieve results of multiple words in the same sentence/paragraph.
- i. List a technique to find other terms related to your search item.
- j. Allow 20 minutes to do a search on a topic specified in the video (blasting accidents).

In-Class Activities:

3. The class met in a computer room, with the librarian, for a hands-on workshop using the techniques showcased in the video. Part of the purpose for the hands-on instruction component was to evaluate their search techniques and the results they obtained for the search query, blasting accidents. Students were provided with **Assignment 1B** (Appendix B) that was to be completed before leaving the class. Questions included:
 - a. How many times did you watch the video?
 - b. Have you had library instruction before? If yes, in what class?
 - c. What was your confidence before this video/tutorial?
 - d. What was your confidence after?
 - e. Which model of instruction did you prefer and why?

Please note: A peer evaluation was done of the librarian for the purpose of providing as complete an assessment of this teaching methodology as possible. Feedback from the evaluator is also provided below in the results section.

4. The students were requested to provide one article obtained through interlibrary loan before the end of the term, detailed in **Assignment 1C** (Appendix B); so that they could experience how easy it is to retrieve material that is not available in the campus library.

Throughout the course, the instructor noted the reference of all materials presented in the lectures in order to demonstrate the variety of sources available; such as: scholarly and/or grey literature in mining engineering, as well as, the value of the research process and how it affects the construction of knowledge. The students were assigned an overarching research project and tasked with presenting on a topic that was not covered in this course, or to cover a topic in greater detail than was covered in this course. They were encouraged to use all sources of information including but not limited to Wiki, Google Scholar, web resources (government and industry), books,

subscription based online access to conference proceedings and journal articles available through the library.

Results

The 13 students were asked to rank their confidence (out of 5) before and after the library instruction. The average confidence before was 2.8 (standard deviation 1.2) and after was 4.3 (standard deviation 0.5). They watched the video an average of 1.7 times. Comments from students included:

- It was easier to learn research techniques this way than in the earlier lecture style they had received from a design class. With the large class, it was hard to focus and easy to be distracted.
- The tutorial and video complimented each other to make it great.
- The computer tutorial can be good for direct information but the lecture format is good because with the large class size, someone may ask a question that others may not think of.
- The video was great because I could re-watch the parts I missed when trying to answer the written assignment.
- Lecture format is more interactive and allows questions to be asked.
- The video allows you to work at your own pace.

Overall, the general impression from the student feedback was that a combined video and lecture assignment was effective as each method of teaching has its strengths. Their before/after statistics regarding confidence suggest that the two hours invested in participating in both activities greatly improved their learning over the lecture based method most had experienced in another class. Several students complained that this type of instruction helped them so much that they wish they had been taught this in 1st or 2nd year, and not in 3rd or 4th year.

Comments from the peer evaluation included the following:

- The room and audiovisual equipment was set up and ready to go before the class.
- The librarian engaged and chatted with the students as they entered the classroom. The students chose seats at the front of the classroom, leaving the back rows empty. Was this because they saw the librarian in the video and were comfortable sitting close to the front?
- It was apparent that the students had watched the video and easily answered questions testing their knowledge of the video.

- As the librarian “added value” to the session by sharing some of her favourite tips and tricks, students busily jotted notes.

30% of the mark for the student’s research projects was allotted to documenting and demonstrating the research process. This provided further feedback on their comfort with the research process, as noted by the students during their final presentations:

- LiDAR: most of the information from this cutting edge technology had to be found online in journals. Key words had to be adjusted to the mining discipline as typical applications were in geotechnical terms.
- Oil Sands: grey literature was more useful than the traditional research methods that rely on scholarly journals. Government and industry websites provided more readily accessible papers than did the university search engines.
- Blast Overbreak and Damage: discovered a key paper on the topic and then conducted a lateral search for additional articles published by the same author. This group identified that they were successful using textbooks to lead them to reports related to their topic area, in an attempt to find multiple sources of information and remove bias caused by using limited sources.
- Perforation in Oil Fields: utilized the OnePetro database by the Society of Professional Engineers (SPE) and benefitted from its highly specialized content.
- Blasting Through Pipelines: determined that on-line spreadsheets could be used to identify relevant formulas and those formulas could be cross referenced to literature.
- Accidents related to Ventilation: relied on a Google search to identify incidents that had not been easy to retrieve in academic papers through the use of broader keywords.

Discussion

This study shows that there was a benefit for the librarian to engage the students with library instruction that was relevant to classroom activities, and as such the format in which the information was delivered was very important. There is no disputing that signals of boredom are simply more obvious in the classroom as students disengage with the material and start ‘playing on their phone, tablet or laptop’. The flipped teaching methodology can be more challenging for instructors and librarians as providing this delivery mechanism requires creativity, time, and a reliance on active

learning principles such as peer-to-peer learning and sharing of information, yet, student engagement increases due to their participation in active learning activities.

Another benefit for this particular class was that there were only 13 students. This smaller class fostered discussion and gave every student a chance to be heard. Similar classes in the engineering program typically utilize a lecture style format when teaching research methods, in classrooms of up to 120 students at a time. Students benefit from smaller class sizes where they have the freedom to ask questions, participate in peer-to-peer learning and work in small groups. Flipped teaching can employ a number of different teaching methodologies ensuring that all students regardless of learning style (visual, auditory, etc.) have an opportunity to discuss their thoughts or opinions and ask questions. In pre-planning, larger classes could be subdivided into smaller groups to capitalize on the delivery of information literacy instruction as a lot of time is available throughout the semester for group work. Another option would be to have the librarian work with individual teams to assist in the initial literature searching on their topic. Students in GeoE 498 acknowledged that they would have benefited from this type of learning in 2nd year, so further discussion is needed with faculty members teaching those courses to identify if this type of instruction would be feasible.

Conclusion

Using flipped teaching requires significant planning in advance, for instance, discussion for this particular project was initiated in October, and the instruction was delivered the following January. The video appealed to these students because they could learn at their own pace and then apply these skills to a research project that accounted for 10% of the overall mark. But it was always stressed that this is a technique that they can benefit from in the working world too.

The student projects very much highlighted what the instructor experienced while preparing the course. In the field of engineering, it is very important to critically evaluate all sources of information including textbooks, on-line journals, industry websites, newspaper articles, government websites, YouTube videos, etc. Mining is a fairly small community and those involved are using the internet to provide resources that allows them to stand out amongst their competitors. The information is out there and depending on the topic, different resources are more helpful than others.

Organizations like the ISEE (International Society of Explosives Engineers), ISRM (International Society for Rock Mechanics) and CIM (Canadian Institute of Mining, Metallurgy and Petroleum) are starting to post technical libraries on-line. We must teach the engineering students not only how to access these resources, but also the

importance of becoming future contributors. This simple video-lecture model is the first step in interactively teaching the students to continue to learn after they have moved on from a learning institution where subscription based scholarly information is readily accessible.

Finally, this example of flipped teaching could be applied successfully in any problem based classes. If part or all of the theory was delivered through videos, this would leave class time for additional sample problems. Professors could provide fill-in-the-blank worksheets or mini quizzes to be sure that students are familiarizing themselves with the theory before class. A typical engineer wants to know how things work and why and routinely uses technology to find answers to questions personally and in their school life. This teaching style reflects this modern day need for quick answers to questions.

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Name: _____

GeoE 498.1 Assignment 1 Part A

Library Search Techniques

Due Date: Start of the tutorial period, January 13, 2014 (2:30-3:30, Room 161, Murray Library).

Requirement: For this assignment, you are to log in to PAWS and view the 10 minute library instructional video labeled: "Assignment 1 - Search Techniques".

Answer the following questions:

1. What U of S website address is required to access USearch? _____

2. What is the first search item used? _____

FYI. You will have a lecture based on this topic later in the term. It should include a demo.

3. Provide examples of limiters for refining search items on the screen.

4. When using the advanced search engine, how do you search for groupings of words?

5. What does it mean when a title is highlighted in blue?

6. For the search from within Engineering Village:

a. What is a bibliographic database?

b. What is a technique to exclude results from search items?

c. What is a technique to retrieve results of multiple words in the same sentence/
paragraph?

d. What is a technique to find other terms related to your search item?

7. Practice search techniques for the other topic specified in the video. Allow 20 minutes.

The term is: _____

Either below or on another sheet, note key search words, databases, etc. used to find information that excludes coal operations.

Jot down any questions you may have. You will need these notes to complete Assignment 1B in the tutorial session.

Name: _____

GeoE 498.1 Assignment 1 Part B

Library Search Techniques

Due Date: End of the tutorial period, January 13, 2014 (2:30-3:30, Room 161, Murray Library).

Find links for blast related accidents, and write below.

Ideas:

- Not scaling loose
- Failure to clear blast area
- Inadequate vehicle maintenance
- Not checking tag board
- Premature blast
- Misfire
- Harry Verakis
- Drilling into mishole
- Flyrock
- Centralized blast system
- Premature detonation
- Fall protection
- Blast area security
- Thomas Lobb

Search Engine	Search Word	Link

ANSWER QUESTIONS ON REVERSE

