FROM THE PRINTING PRESS TO YOU TUBE – WELCOME TO THE WORLD OF LECTURE 2.0

Ronald J Hugo

Schulich School of Engineering, University of Calgary

ABSTRACT

This paper compares student performance in a third-year core Mechanical Engineering Thermodynamics course using a traditional lecture-based form of delivery with that of a blended mode of delivery. The blended mode of delivery includes online lectures delivered by YouTube and peer instruction delivered through active tutorials. The paper finds that student performance in the blended mode of delivery is at the same level as it was with live delivery. It is speculated that this level of student performance is achieved by the fact that the blended mode of delivery addresses the learning needs of students on multiple dimensions. Student course evaluations in the blended mode of delivery were found to decrease in comparison to the live delivery; however, as technology advances these differences will be reduced.

KEYWORDS

Blended Learning, Online Delivery, CDIO Standards 3, 7, and 8

INTRODUCTION

The modern day university was born out of a collective of charismatic scholars who were able to entertain, enthral, educate and attract students from across Europe to cities such as Bologna, Oxford, Paris, Padua, Prague, and Vienna. These masters, as the scholars were called, developed and delivered their own lectures. In the process, they educated students in the liberal arts, theology, law and medicine (DeMillo, 2013; Georgedes, 2006). Although the masters often travelled to other Studia Generale across Europe to share documents and learnings, the invention of the printing press in 1450 suddenly made it possible for the learnings of one master to be delivered by another, even perhaps a less skilled master, at another Studia Generale. Through this evolution, the structure of the modern day university was born: professors of varying lecturing abilities were able to deliver similar curricula using textbooks of a common root.

Presently, another evolution or, perhaps, revolution is taking place. Through the development of broadband internet, non-volatile storage, inexpensive computers with significant processing capability, and easy-to-use software, it is now relatively simple for anybody to develop, record, and broadcast a lecture through media sites that have global reach (Khan, 2012). With this development, the lecture has become fully liberated, and in certain respects a reversal is underway whereby the masters can now be made available to the students, irrespective of student location, with the potential to transform our view of the modern-day university (Bowen, 2013).

With this change comes new opportunity. The earliest adopters of this technology have found that by placing the lecture online, it is now possible to free lecture time for other higher-level learning activities, such as active learning (Svinicki et al., 2014). Beyond CDIO Standard 8 (Active Learning), however, other types of advances are starting to be realized, such as the unbundling of the lecture, a course, or even a degree (Selingo, 2013). New learning experiences can now be imagined and constructed whereby content from different courses are packaged together, enabling Standard 3 (Integrated Curriculum) and Standard 7 (Integrated Learning Experiences) to be considered in ways not previously possible with traditional lecture delivery methods.

Research Questions:

In the Fall of 2013, an experiment was conducted whereby a third-year (junior level) Mechanical Engineering course was offered in a blended format using YouTube for the online content delivery. Although the content was developed and delivered specifically for students registered in a course at the University of Calgary, it was also possible for students not registered in the course to watch the content. As part of the investigation, viewing data for students in Canada (assumed to be those taking the course) is compared to viewing data for students in the United States. The nature of what students watched, for how long, and when will be examined and compared. This will provide an indication of how students are using this new media for learning purposes, and it will also provide a glimpse into how it can be used for other advances in engineering education pedagogy, specifically in relation to CDIO Standards 3 and 7.

BACKGROUND

The Mechanical Engineering Thermodynamics course was delivered during the Fall 2013 semester which spanned 13 weeks from early September to mid-December. A total of 92 third-year (junior) Mechanical Engineering students were enrolled in the course. The course is the second in a two-course sequence taken by students in the Mechanical Engineering program at the University of Calgary, and course content includes three weeks of review of the previous Thermodynamics course followed by ten weeks of material that is new to the students.

This was the sixth time that the course instructor had taught the course. The previous five offerings of the course were from 2001-2005, and there had been an eight year lapse from the last time that the instructor taught the course in Winter 2005. This provided an opportunity to compare student performance from the 2001-2005 time period with student performance in Fall 2013.

It is realized that students themselves have changed between 2001-2005 and 2013, and one could argue that a more direct comparison would be to split the 2013 class into two groups, with one group attending live or traditional lectures and the second group taking the online blended format. This type of investigation has been performed by others (Bowen et al., 2012), and as reported by Koller (2013) it can be difficult to restrict those taking the live lectures from being able to watch the online lectures, especially when the content is made public. Given the public nature of the YouTube lectures, the 2001-2005 to 2013 data comparison was determined to be the most effective.

Using the online blended format permitted flexibility with the regularly-scheduled lecture time (50 minutes in duration and held 3 times per week). Active tutorials were held once per week during the scheduled lecture time and usually on the days that an assignment was due. Active tutorials typically featured five to six concept questions that pertained either to the assignment material or a review of material in advance of a semester exam. The peer instruction technique of Mazur (1997) was used. Student participation was recorded during the active tutorials using a personal response system, and the weight assigned was 10% of the final course grade. Student answers were also recorded; although, performance was not reflected in the course grade.

This was the first time that the students had taken a course using an online blended format of delivery. While the students indicated that they often used YouTube lectures developed by instructors from elsewhere to supplement their learning in other courses, receiving all of the lectures online was new to them.

METHODS

This section discusses the nature of the student sample, the instruments and measures used, and the procedures by which the instruments and measures were delivered to the student sample.

Sample:

The first year for students in the Schulich School of Engineering is experienced as a common-core year. At the conclusion of the first year, they select their programs. Placement in programs is highly competitive and based on the students' first-year GPA (Grade Point Average). Mechanical Engineering is a popular program choice for students, and the first-year cut-off GPA for the Mechanical Engineering program has averaged between 2.6 and 2.8 on a 4-point scale.

Instruments and Measures:

1) YouTube Analytics Data

With the online content delivered through YouTube, it was possible to use the Analytics package within YouTube to examine and compare viewing statistics. It should be mentioned that watch data for Canada is reported in aggregate for the entire country, and consequently it is possible that some of the reported watch data is due to students that are not registered in the course, such as students at another university. A second source of ambiguity can be attributed to students downloading the YouTube videos and watching them offline, as reported to the course instructor by one student. These two sources of ambiguity would tend to cancel one another out. Given that this was also the first time that the course was offered via YouTube (i.e. the availability of these YouTube lectures was in its infancy and potentially not well known to other Canadian students), it is assumed that the Canadian watch data is mainly attributed to University of Calgary students.

2) Exam Performance

The course included two 50-minute semester or term exams (Exam 1 and Exam 2) that were open textbook (Cengel et al., 2011). Each semester exam was worth 15% of the final course grade, and each exam consisted of two questions. The course also had a 180-minute final examination that was also open textbook and featured five questions. The final exam questions were of a similar level of difficulty (but different questions) to the final examinations administered between 2001 and 2005.

An attempt for direct comparison with live-lecture student performance was made with Exam 1 by setting two questions identical to those from a term exam held in 2003. However, the 2003 term exam was longer, that is, 75-minutes in duration. As a result, it included an additional question that was, by nature, less difficult. At the same time, this less difficult question was on par with one of the two questions on the 50-minute exam. Therefore, while this slightly different structure made the comparison challenging, it was circumvented by doubling the performance on the easier question. In other words, student performance from Fall 2013 on one of the two questions (the easier question) was “doubled” and added to student scores from the more difficult question, thereby simulating student performance on a three-question term exam. Given that the additional question on the 2003 exam was less difficult, this comparison is viewed as being reasonably accurate.

3) Student Course Evaluations

Student feedback was quantified using the Universal Student Rating of Instruction (USRI) instrument administered at the University of Calgary. A second form of student feedback came from student comments provided during a mid-semester student liaison meeting where students normally provide feedback on all courses to a committee that includes several professors and the department technical-staff and administrative-staff managers.

Procedures:

In order to be consistent with the comparison of student performance between 2001-2005 and 2013, the course instructor set and graded all questions for all examinations for all years.

RESULTS AND DISCUSSION

YouTube Analytics Data:

From the period September 1, 2013 to December 31, 2013, total global viewership was spread across 125 countries with a total of 159,400 watch minutes and 40,700 views (3.92 minutes per view). During this time period, Canadian students had viewed over 83,000 minutes of video with approximately 18,000 views (4.61 minutes per view), and in the United States students from all 50 states and the District of Columbia had viewed over 38,000 minutes with approximately 9,000 views (4.22 minutes per view).

The number of views and watch minutes for viewers in both Canada and the United States are shown in Figure 1. Characteristic peaks and valleys are noted in the data and these most often correspond to the weekly cycles of a student’s life. Watch data for Canada remains relatively constant throughout the duration of the course, while the watch data for the United States is seen to grow as an increasing number of students are able to find the content on YouTube given the relation between search rankings and view statistics.

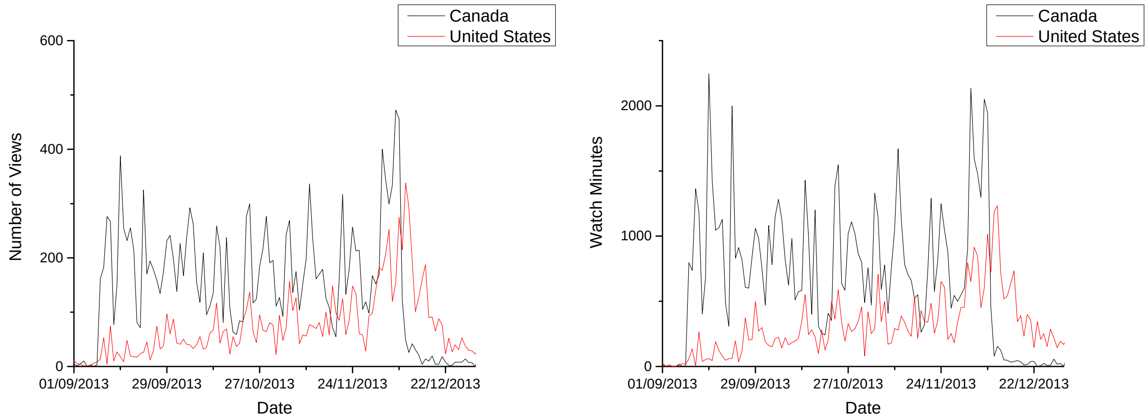

Figure 1. Number of Views (left) and Watch Minutes (right) During the Course

A more detailed interpretation can be obtained by examining how watch minutes correspond to the weekly cycles, as shown on the left in Fig. 2 where each Friday is indicated by a vertical line. It is interesting to note that watch minutes for Canadian students are often reduced on Fridays, indicating that University of Calgary students tend to do less school work on Fridays than they do on other days of the week. This trend is less pronounced for students in the United States, possibly due to the fact that students in the United States are dispersed geographically with differing deadlines for the courses that they are enrolled in, providing differing motivations for content viewing.

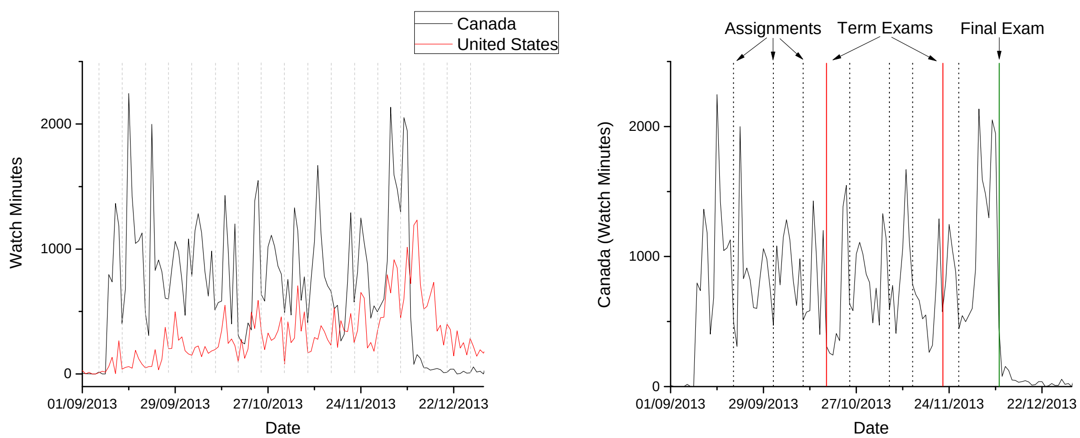

Figure 2. Watch Minutes by Week:
Canada / US Watch Minutes with Friday Denoted by Vertical Lines (left)
Canadian Watch Minutes with Course Milestones (right)

Canadian watch minutes are plotted along with course milestones on the right in Fig. 2. Course milestones include dates that assignments are due, dates that term exams are held, and the date for the final exam. The data suggests that students do not watch additional video content prior to weekly assignments, but there is a moderate increase in watch minutes prior to semester exams. Watch minutes prior to the final exam increased significantly, providing strong evidence that students used the content while studying. This increased viewership is also noted in the data for the United States; however, the final exam peak is spread over a longer period of time due to the fact that students are geographically dispersed with final exams spread over the first few weeks of December. It was interesting to note that watch minutes in the United States do not go to zero over the Christmas break as they do in Canada. This may be attributed to some final exams taking place in January, thereby forcing students to study over the Christmas break.

In a traditional live lecture-based course, an instructor can take attendance to determine how many students are attending the class. An online version of “attendance” is presented in Fig. 3 where the weekly Canadian view minutes are divided by the number of content minutes posted for that week multiplied by the number of students in the course. If all students watched all of the content provided, this number would be 100%. The fact that the value exceeds 100% during Weeks 10 and 13 indicates that students are not watching the online lectures regularly but rather cramming before an exam. Cramming in this sense is not possible when the lectures are live (you either attend or you do not), but it is possible when the lectures are online. The average online attendance for the course was computed to be 66.3%. When the course instructor taught the course from 2001 to 2005, the average class attendance was 65.8% as indicated by student participation in the USRI. Consequently, the online attendance data presented here is not significantly different from the data collected when the course was taught in person.

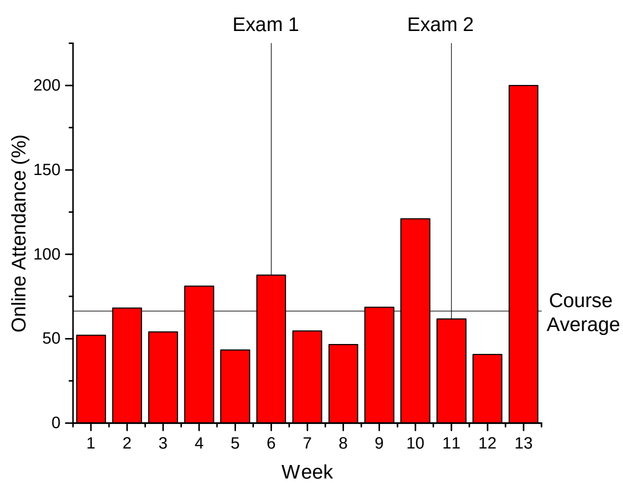

Figure 3. Canadian “Online Attendance”
(Weekly Minutes Viewed / Weekly Minutes Available)

What is perhaps most revealing from the YouTube data is a contour plot of the Canadian cumulative watch minutes by lecture video segment and by day, as presented in Fig. 4. Also indicated on this plot are the major course topics, dates of major exams, and the lecture segments that have example problems in them.

The data indicates that student watch minutes tend to decrease as the semester progresses, as indicated by comparing cumulative watch minutes for topics like Gas Mixtures and HVAC to topics like Review and Gas Power Cycles. It seems as though the students begin to lose stamina starting at about Day 60 (51 days into the term given that the course Begins on Day 9). It is also noted that students take a reprieve from watching lectures around the time that a term exam takes place. It was also observed that when students cram for the final exam, they appear to do so by watching content across the entire course (all Lecture Video Segments) versus only watching content for the last two topics (HVAC and Combustion).

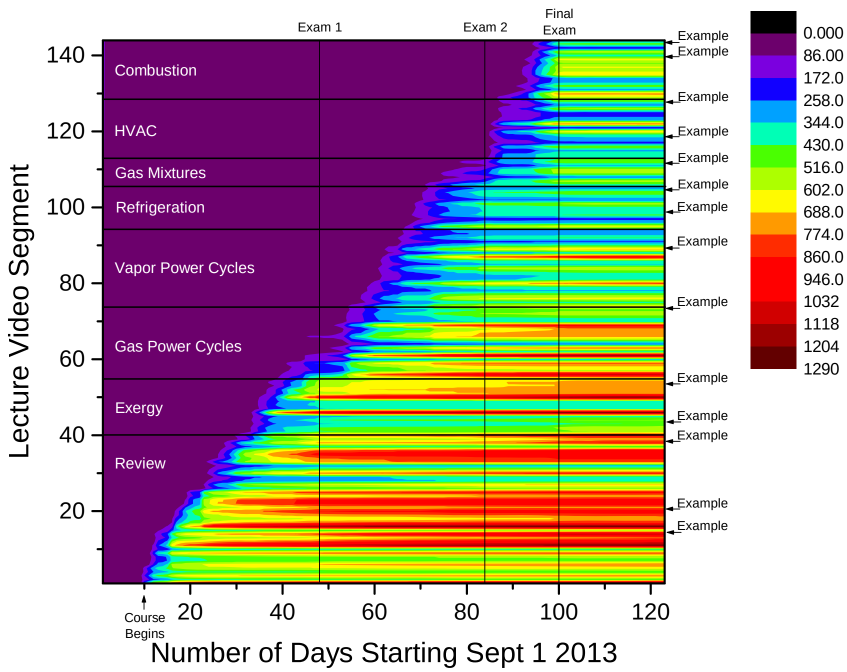

Figure 4. Cumulative Canadian Watch Minutes by Lecture Segment and Day

Comments received via YouTube indicate that students of different disciplines (Chemical Engineering, Mechanical Engineering, etc.) are using the content to support a variety of courses. This suggests the ability to reuse components of the online modules in other courses, even crossing engineering disciplinary boundaries. The Review module in addition to Gas Mixtures and Combustion could be used to initiate a more advanced course on Combustion, for example. The ability to either reuse or mix-and-match modules from different courses offers new possibilities for engineering education, especially in an integrated manner as suggested by CDIO Standards 3 and 7. This enables us to imagine curricula that go well beyond the current rigid course structures that are often difficult to alter.

Exam Performance:

Having examined student behaviour in terms of when they watched the online content, it is now instructive to examine how students behaved on the major exams. In what follows, their performance on two exams will be compared. The first comparison will be performance on Exam 1 which will be compared to student performance from an almost identical exam that was offered in Winter 2003. The second comparison will be between performance on the 2013 final exam and the final exams offered from 2001-2005.

Figure 5 shows a histogram comparing student performance on Exam 1 between 2003 and 2013. The exam offered in 2013 was nearly identical to that of 2003 with the exception of one question. In order to compare exam data sets, student performance on question one was doubled and summed with student performance on question two. This enabled a comparison to the three-question exam given in 2003. Given that question one was of similar difficulty to question three from the 2003 exam, it is believed that this approach provides a reasonable approximation for student performance. The average score on the two exams is close, with more students placing between 90% and 100% in 2003.

Figure 6 compares student performance on the 2013 final exam with student performance from the final exam in the previous five offerings of the course (2001-2005). The average grade on the final exam in 2013 (70.1%) is very close to the average grade obtained by students in the previous five years (69.2%). The distributions are also quite similar, with standard deviations being only 0.5% apart for the two data sets.

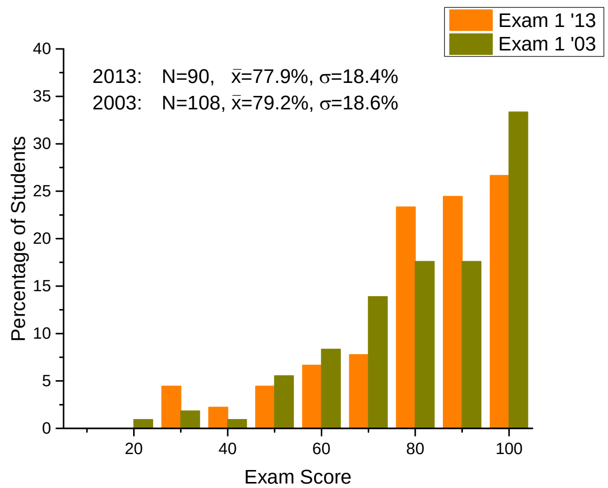

Figure 5. Student Performance on Exam 1 – 2013 versus 2003

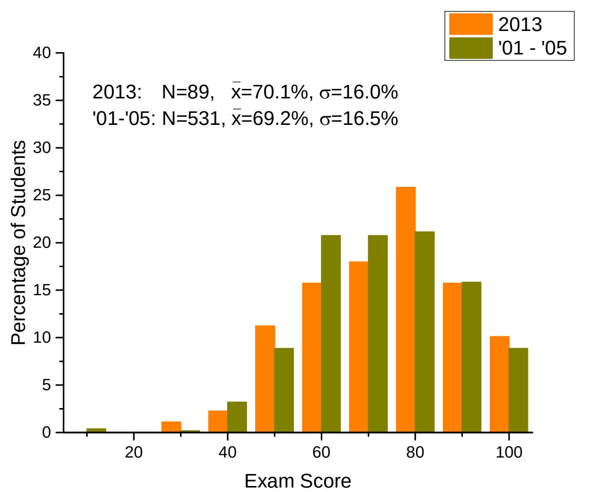

Figure 6. Student Performance on Final Exam – 2013 versus 2001-2005

By examining student performance between the traditional lecture-based course format (2001-2005) and the blended format from 2013, it is difficult to see any significant difference in student performance as quantified by either term exam or final exam. It is believed that this is in part due to the fact that the blended mode of delivery addresses the learning needs of students on multiple dimensions (Felder et al., 2005). The four dimensions characterized by the Felder-Silverman learning style model include:

1. **Sensing-intuitive** – the lectures themselves were designed to have a mixture of facts and procedures balanced by theory and meaning. This was reflected by a student comment *"Great lectures – good mix of theory and examples,"* as reported from the student liaison meeting.
2. **Visual-verbal** – the lectures included a combination of pictures and videos of real-world systems in support of the traditional written and spoken lecture content.
3. **Active-reflective** – the active tutorials featured the peer instruction approach of Mazur [6] which provides students with an opportunity for active learning. The homework assignments were intended to be completed individually, providing students with a more reflective learning style with an opportunity for practice.
4. **Sequential-global** – the ability for students to watch the lecture content sequentially and follow the chronological course design (assignments, term exams, final exam) or watch any lecture that interests them is made possible using the online delivery format.

The fact that the blended delivery model addresses the learning needs of students on multiple dimensions should result in a positive student learning experience for most students. It is believed that this is then reflected by student performance as quantified by both the term exam and the final examination.

Student Course Evaluations:

A final comparison is possible by examining student course evaluations as quantified by the University of Calgary Universal Student Rating of Instruction (USRI). It should be noted that the USRI administered in 2013 was done so immediately after the second midterm, an exam on which the students did not perform very well (a class average of 50.7%). The timing of term exams, the resulting student performance on these term exams, and when the USRI is administered can sometimes influence the way that students complete the survey.

The USRI instrument evaluates student experience by questioning students on twelve rating items:

1. Overall Instruction
2. Enough detail in course outline
3. Course consistent with outline
4. Content well organized
5. Student questions responded to
6. Communicated with Enthusiasm
7. Opportunities for assistance
8. Students treated respectfully
9. Evaluation methods fair
10. Work graded in reasonable time
11. I learned a lot in this course
12. Support materials helpful

The results of the USRI instruments are shown in Fig. 7 from which it can be seen that values for the 2013 blended offering decreased. The most notable decrease was with Rating Item 7 – *Opportunities for Assistance*. This is most likely attributed to the fact that direct student-to-professor contact was reduced by 66%, and students often use the time after lecture to ask questions. It is also attributed to the fact that the course instructor was the Department Head during the 2013 course offering, and student assistance was only provided if students first made an appointment with the Department Administrative Manager. During the 2001-2005 course offerings, student assistance was provided on a drop-in basis with an open door policy.

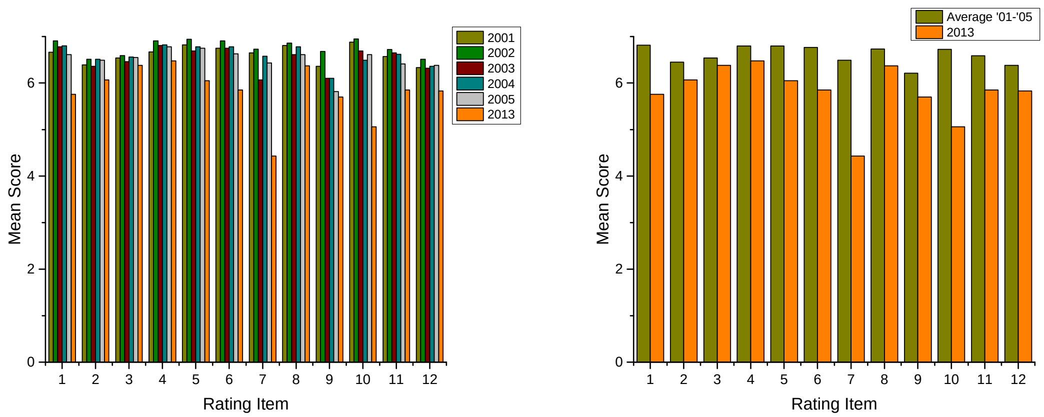

Figure 7. Student Evaluations (USRI)
Yearly Comparison (left) and Averaged Comparison (right)

A second noteworthy result from the USRI instrument data is Rating Item 1 – *Overall Instruction*. This was reduced from an average of 6.81 to 5.76. This reduction is attributed to a number of factors, but most likely due to the fact that it is more difficult to develop connections with students when contact is restricted to active tutorials held once per week. During live lectures, an instructor has more opportunities to develop personal connections with students, and these opportunities for developing connections are reduced with the blended mode of delivery. This is also reflected by the reduction in Rating Item 6 – *Communicated with Enthusiasm* which went from 6.76 to 5.85. It is more challenging to interact with students in a traditional sense with the online lecture format. All of these lead to a reduction in Rating Item 6.

It is important to note that, although the Mean Score on Rating Item 1 – *Overall Instruction* was found to decrease from 6.81 to 5.76, the Mean Score of 5.76 is still actually quite good. The score of 5.76 is higher than the department average of 5.59 for similar third-year Mechanical Engineering courses, and it is also higher than the faculty average of 5.33 for similar third-year courses offered across all of Engineering.

A final form of student feedback came through the mid-semester student liaison meeting. A number of notable student comments include:

> *"The online lectures are very convenient as you can watch them on your own time; although, I don't think there is any substitute for face-to-face interaction. It is also frustrating to not be able to ask questions while watching lectures. Also, more opportunities to ask questions would be appreciated."* - Reflecting USRI Rating Items 1, 5, 6, and 7

> *"Very good professor, however, isn't available very often."* - Reflecting USRI Rating Item 7

Some of the more positive comments include:

> *"Lectures online are well-done, and are as effective as regular lectures (if not better)."*

“Extremely helpful to be able to pause and follow online lectures.”

“Love the ability to go back through lectures.”

“I prefer the online lectures as it allows me to pace myself when studying / learning.”

It is interesting to examine one of the student comments in further detail:

“Does very well with the little time that he has – seems to have interest in the topics.”

The comment *“seems to have interest in the topics”* reveals one of the challenges of online delivery. This is reflected by the reduction noted in Rating Item 6 – *Communicated with Enthusiasm* from 6.76 down to 5.85. The Course Instructor was very interested in the topics, and this level of interest did not change between the live lectures and the recorded lectures. However, without the advantage of presence, it is challenging to convey this level of enthusiasm. In some respects, the online lectures are in a similar state to the early years of cinematography where the quality of acting recorded by a motion picture lacked the presence achieved by live theatre. This evolution was illustrated by director Martin Scorsese in the major motion picture Hugo (Sarma, 2013), which chronicled the evolution of the French cinematographer Georges Melies. It is relatively certain that both technology and technique will advance with time, and this difference will be minimized and eventually at some point the experience of online delivery will exceed that of live delivery. When this point is reached, the modern university will enter into a new era.

CONCLUSIONS

This paper provides a detailed comparison of student performance in a third-year Mechanical Engineering Thermodynamics course between traditional live lectures and a blended delivery model involving online lectures and active learning tutorials. The results demonstrate that students learn as effectively with the blended learning format as they do with the live lecture format. Hence, it is believed that the blended mode of delivery addresses the learning needs of students on multiple dimensions, compensating for reduced direct student-to-professor interactions. Despite these positive learning outcomes, the students still find aspects of blended delivery less appealing than live delivery, specifically *Communicated with Enthusiasm* and *Opportunities for Assistance*. As the technology for online delivery improves, however, these differences will be reduced.

The paper also demonstrates that even with the limitations of current technology, the level of instruction as reported by the USRI instrument is still higher than both the department and faculty averages for similar-level courses delivered with a live-lecture format. This offers promise for online lectures and the blended mode of delivery as the methodology will only continue to improve as the technology advances.

Consequently, it is possible for YouTube to achieve what the printing press once achieved, only now with a subtle change. With the printing press, it was possible for others, in addition to the original masters, to deliver the content of the masters to students at geographically distributed Studia Generale. In this new evolution to Lecture 2.0, students will be able to choose which masters they wish to access.

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BIOGRAPHICAL INFORMATION

Ronald J. Hugo is Professor of Mechanical and Manufacturing Engineering and Associate Dean (Teaching & Learning) at the University of Calgary. He is also the holder of the Engineering Education Innovation Chair in the Schulich School of Engineering. His research interests are in the areas of experimental fluid dynamics, energy systems, and engineering education.

Corresponding author

Dr. Ron J Hugo
University of Calgary
2500 University Dr. NW
Calgary AB Canada T2N 1N4
hugo@ucalgary.ca