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The Effectiveness of Webinars in Professional Skills and Engineering Ethics Education in Large Online Classes

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Brendon is an ”out-of-the-box” engineer with degrees in engineering and philosophy. He is passionate about using webinars and online learning tools to engage learners on their own terms. When students feel comfortable they ask more questions and participate in activities and discussions about the material, thus increasing retention and student satisfaction.

After 10 years of industry experience Brendon became an engineering technology instructor at the Southern Alberta Institute of Technology in 2012. He has been a sessional instructor at the Schulich School of Engineering at the University of Calgary, where he completed his MSc. in engineering researching engineering education.

His roots in industry aided him in the development of curriculum for 3 new courses by aligning industry’s desired competencies for new grads with accreditation criteria and facility constraints. The result was applied education: practical learning activities and hands-on labs that prepared students for the real world and accelerated their time-to-competency once on the job.

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Abstract

Online learning is revolutionizing education, especially in post-secondary institutions where class sizes are already in the hundreds. Engineering-science-based courses are ideal for online learning with their focus on formulas and solving numerical problems. The black and white nature of technical content makes it easier to communicate via concrete video lectures and examples as well as automatically assess in a mass-production fashion (Hugo, Brennan, 2016). What about teaching non-technical engineering courses online to hundreds or thousands of students?

ABET student outcomes for professional skills are qualitative in nature. Therefore, they require qualitative assessment because of the wide range of possible solutions inside the gray zone (Shuman, 2005). How can hundreds of students achieve these outcomes in an online course without sacrificing the quality of teaching and learning and the rigour of assessment? This study explores the unique challenges of teaching a large online courses that meet ABET's student outcomes of: professional and ethical responsibilities, and knowledge of the impact of engineering technology solutions in a societal and global context.

In 2014, an undergraduate engineering course on professionalism, ethics and life-long learning was taught to 411 students through the University of Calgary's Schulich School of Engineering. The blended learning methods available to students were: traditional in-person lectures, video livestreams of the lectures, asynchronous video recordings of the lectures, the required course textbook and there was a discussion forum where participation was optional.

Students were assessed through a combination of online quizzes and two qualitative assessments: a written case-study analysis of an industrial disaster and a 10-minute video presentation of the student analyzing an ethical dilemma and arriving at a decision on what they would do.

One year later, the course was taught online to 468 students by the same instructor. This time the course was purely online with synchronous webinars replacing the in-person lectures in a theatre. Discussion forum participation became a mandatory gradable component. The intention was increase opportunities for interaction with the instructor and fellow students (Lumgair, 2017).

Students of both courses were surveyed on their perspectives and preferences with regards to: the presentation formats of course content delivery, engagement levels and perceived effectiveness of each format and the effectiveness of the assessments in evaluating student outcomes.

In summary, utilizing live interactive webinars correlated to increased learner engagement and effectiveness ratings and are recommended as an online teaching and learning tool that ought to be added to blended online courses in place of livestreaming in-person lectures, or in addition to pre-recorded video lectures. Professional skills learning outcomes and criteria can be met through online courses conducted with hundreds of students, if rigorous qualitative assessments are issued and there are enough hours allocated to the loading the instructor and teaching assistants to maintain accreditation criteria standards.

Introduction and Research Problem

Online learning is revolutionizing education, especially in post-secondary institutions where class sizes are already in the hundreds. Engineering-science-based courses are ideal for online learning with their focus on formulas and solving numerical problems. The black and white nature of technical content makes it easier to communicate via concrete video lectures and automatically assess in a mass-production fashion (Hugo, Brennan, 2016). What about teaching non-technical engineering courses online to hundreds or thousands of students?

Of the 11 ABET student outcomes and the 12 Canadian Engineering Accreditation Board's (CEAB) graduate attributes, about half are "technical / hard skills" and half are "professional / soft skills" (ABET, 2018 & CEAB, 2017). The student outcomes for professional skills are qualitative in nature. Therefore, they require qualitative assessment because of the wide range of possible solutions inside the gray zone (Shuman, 2005). How can hundreds of students achieve these outcomes in an online course without sacrificing the quality of teaching and learning and rigour of assessment?

In Spring & Summer semesters of 2014, an undergraduate engineering course on professionalism, ethics and life-long learning was taught to 411 students through the University of Calgary's Schulich School of Engineering. The blended learning methods available to students were: traditional in-person lectures, live video stream of the lectures, asynchronous video recordings of the lectures, the required course textbook readings and there was a discussion forum where participation was optional. This combination of presentation formats is similar to those offered in Massive Open Online Courses (MOOCs).

After the grades had been finalized, the students were invited to voluntarily participate in an online survey about the course and their grades were linked to their survey responses through their ID numbers. The pilot study survey (and class attendance) revealed that most of the students consumed course content by watching asynchronous video recordings of the lectures and reading the textbook.

One year later, in the Spring semester of 2015, the course was taught to 468 students by the same instructor. This time the blended learning methods changed from in-person lectures in a theatre to synchronous webinars. Discussion forum participation became a mandatory gradable component. The intention was increase opportunities for interaction with the instructor and fellow students (Lumgair, 2017). Again, the students were invited to voluntarily participate in an online survey about the course and their grades were linked to their survey responses through their ID numbers. The intentional change in learning formats inspired this research question:

> *Can engineering ethics and professional skills learning outcomes be effectively taught and assessed using a blend of synchronous webinars and asynchronous learning methods in a large online class when compared to a blend of traditional in-person lectures and video recordings thereof?*

Purpose and Motivation Statement

The purpose of this study was to understand what happened when an undergraduate engineering course with professional skills outcomes was taught purely online to a large number of students using a blend of synchronous webinars and asynchronous videos, textbook readings and discussion forum participation.

The effectiveness of synchronous webinars in replacing traditional in-person lectures as a blended learning method was evaluated through the comparison of the results of student surveys, final grades and grade distribution.

Background and Justification

The inherently impersonal nature and anonymity of most online courses, combined with potentially enormous class sizes poses new challenges to maintaining the quality of teaching and learning as well as the rigour of assessment.

John Biggs' created and refined the constructive alignment model for course design (Biggs & Tang, 2011). It was recognized by the engineering education organization known as the CDIO Initiative (Conceive, Design, Implement, Operate) (Crawley, Malmqvist, Östlund, & Brodeur, 2014). Crawley summarized constructive alignment as, "The purposeful relationship between intended learning outcomes, teaching and learning activities, and assessment…. The constructive alignment concept represents a systems view on courses." (Crawley et al., 2014)

It has been proposed, "that three hurdles have impeded the development of viable tools to assess engineering students' attainment of the professional outcomes: a consensus about definitions, the scope by which the outcome is assessed, and the nature of the outcome itself." (Shuman, Besterfield-Sacre, & McGourty, 2005). For example, ABET's student outcome criteria 3f. is: "an understanding of professional and ethical responsibility" (ABET, 2018). The verb "understanding" is problematic because it is very difficult to observe if a student understands something (Biggs & Tang, 2011). "Understanding" is also a relatively low-level category of cognitive learning according to Bloom's taxonomy (Bloom, 1956). Whereas, comprehending, analyzing, and making a decision about an open-ended problem such as an ethical dilemma is a very high-order cognitive function requiring one to utilize skills from the "Analyze" and "Evaluate" levels of Bloom's taxonomy (Anderson & Krathwohl, 2001).

All things being considered, the CEAB (and ABET) made the graduate attributes (and student outcomes) as general on purpose in order to allow universities the flexibility to be innovative in how they educate students (CEAB, 2017).

The National Academy of Engineering's (NAE) Center for Engineering Ethics and Society Advisory Group and Infusing Ethics Selection Committee selected 25 *Exemplars of Engineering Ethics Education* (NAE, 2016). In evaluating the applicants' submissions they looked for nine key characteristics. The following are examples of how online learning and webinars could be utilized as tools to help institutions deliver the NAE's exemplary characteristics 1, 4, 7, and 9.

1. **Provides an interactive format that encourages active learning:** Synchronous online learning is when the instructor or TAs meet with students live in real-time through webinars / web conferencing or simple text chat. When used properly, these tools can be highly interactive. Discussion forums allow for asynchronous interactions with the instructor and TAs and amongst the students.
4. **Connects students' ethics learning to engineering practice:** Online learning allows students to take professionalism and ethics classes while on co-op or internship work terms at engineering firms. They are literally immersed in a professional practice and potentially experiencing ethical dilemmas on projects. Students have access to professional engineers to interview for assignments on the ethical dimensions of the Company's work.
7. **Incorporates innovative or creative educational methods:** Online learning provides the environment to utilize a whole host of innovative educational method. As such, it requires creative teaching and learning methods to be employed.
9. **Can be scaled up or easily replicated at other institutions:** Learning Management Systems (LMS) make it possible to have a virtually unlimited number of students in a class. This allows for class sizes that would literally fill the largest sports stadiums in the world. Instructional materials and assignments are typically recorded, saved and stored as electronic files (.pdfs, audio clips, video files, recordings of webinars). This allows for unlimited review of lecture material, explanation of assessments, lab demonstrations etc.. Once the course has been delivered the first time, the materials are compiled and the course can be replicated in future semesters, or exported and shared with other institutions.

For the reasons stated above, it is important to endeavour to teach and assess engineering professional skills online. However, the challenge with large-scale distribution of professional skills education is achieving and assessing qualitative learning outcomes that require a high-level of understanding in Bloom's taxonomy.

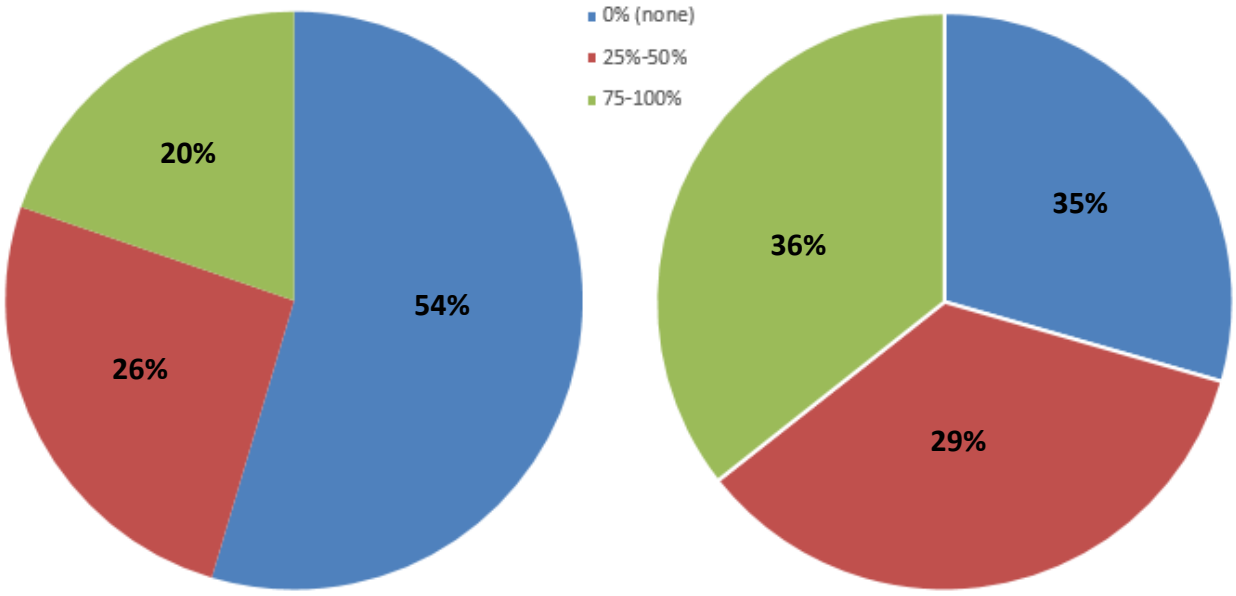
Results and Discussion

The effectiveness of a learning method or course was analyzed in the context of the three categories of Biggs' theory of constructive alignment: teaching and learning activities (TLAs), outcomes and assessments (Biggs et al., 2011).

Effectiveness of Teaching and Learning Activities

In the Spring and Summer semesters of 2014 two synchronous learning methods were available to students: the traditional in-person lectures taught in a theatre on campus and a livestream of the lecture broadcast through the internet. Students were asked what percentage of the in-person lectures they attended (Figure 1) The second year the course was taught purely online with synchronous webinars replacing the in-person lectures (Figure 1).

Figure 1: Percentage of In-Person Lectures Attended in 2014 (left) (*n=152*); Percentage of Live Webinars Attended in 2015 (right) (*n=146*)



In 2014, over half of the students did not attend any of the in-person lectures, contrasted with only one-third of students who did not attend any live webinars in 2015. This represented a 25% increase in individuals who participated in synchronous webinars over the synchronous in-person lectures.

Approximately 20% of the survey respondents indicated they had attended 75-100% of the in-person lectures, plus an additional 6% watched these lectures via the livestream. Comparatively, nearly 36% of the 2015 respondents said that they had attended 75-100% of the live webinars. That means 10% more students chose to attend 75%-100% of the synchronous lectures when they were offered as live webinars instead of in-person lectures (or one-way livestream).

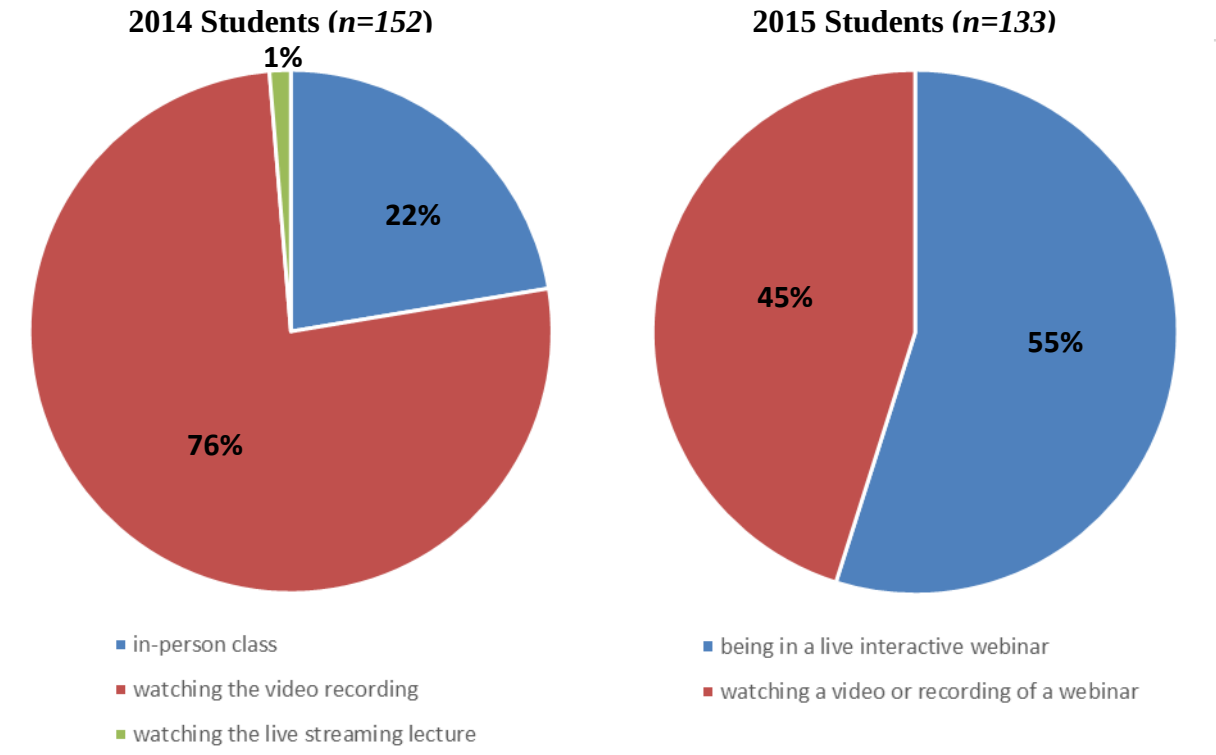
Student comments gathered in the survey and through e-mails indicated that many of them were out of the city on co-op / internship work terms, had traveled back to their home town or country, or were working a full-time summer jobs and chose not return to campus for the evening classes. By offering live webinars as a learning method 10% more students consistently took the opportunity to participate in a synchronous learning method where they could interact with the instructor and peers.

The same types of asynchronous learning methods were available to both sets of students in 2014 and 2015. These included: video recordings of the lectures (in-person or webinar), video recordings of two flipped-classroom style presentations of the instructor speaking into their webcam with no audience, assigned textbook readings and the discussion forum.

Students in both years watched approximately the same amount of videos (by percentage).

About two-thirds of each class watched 75-100% of the videos, and only approximately 6% of watched none. When it came to the percentage of textbook chapters read, the 2014 class read more than the 2015 class. It turned out that 77% of the 2014 students read 75-100% of the chapters compared to 70% the following year.

Figure 2: Students' Most Preferred Presentation Format



The flexibility of blended learning courses provided freedom of choice to the students in terms of how, when and where they consumed course content. Their preferences affected the mixture of how much of each presentation format they consumed. Students were asked which presentation format they preferred most when it came to consuming lecture content (Figure 2).

Only 24% of the 2014 students preferred the in-person lectures or livestream of the same. Figure 2 illustrated that when given the choice, the majority of students (55%) preferred live webinars over watching pre-recorded video lectures or recordings of past webinars. Double the number of students preferred the synchronous webinars over the in-person lectures. This relative comparison needed to be tempered with the fact that less than half of the 2014 students actually experienced an in-person lecture in the course.

In the first year the discussion forum was open for students for Q&A with the instructor and interaction amongst students. This was completely voluntary and no marks were gained by participating. In the second year, the course outline was changed to assign 6% of the final grade to discussion forum participation. The expectation was that students would ask one question (start a thread) and reply to five other people's threads with a meaningful contribution (not just "Liking" their post). This resulted in a nearly a ten-fold increase in the number of forum replies

per student enrolled (0.62 replies per student enrolled in 2014 compared to 5 replies per student in 2015). The shear quantity of threads and replies in the forum increased exponentially from 290 to 3182. There were a few anonymous complaints of people plagiarizing or copying and pasting forum posts in order to get their six posts complete. In 2014 the instructor moderated the forum. With ten-times the activity in 2015, moderating the individual forum discussions became unmanageable for the instructor and TAs. LMS statistics reported the number of posts each student wrote and that information was used to assign their discussion forum participation mark. Random spot checks were carried out by the instructor to assess the quality, thoughtfulness and relevancy of the posts and replies.

Engagement Ratings of Presentation Formats

Increasing learner engagement has been one of the primary goals of modern education. The 2015 students were asked, "How engaged did you feel in the lecture? 1 being least engaged and 5 being most engaged." and needed to rate their engagement by presentation format (Table 1) (Lumgair 2017).

The average student felt most engaged in the live webinar which had a weighted average of 3.45 out of 5 (Table 1). Live webinars were given the highest rating (5 out of 5) by more students than all the other presentation formats combined.

Table 1: Engagement Ratings by Presentation Format in 2015

Presentation Format	***n***	**Engagement (Weighted Average) scale of 1 to 5**	**Percentage of students that gave the format a "5 out of 5" engagement**
Live Webinar	103	3.45	12.2%
Webinar Recording	133	2.53	1.5%
Video of Instructor presenting to audience in a theatre	132	3.11	3.0%
Video of Instructor presenting into a webcam	133	3.15	6.1%

A series of Spearman's rank-order correlations revealed there was a medium positive correlation between the number of live webinars that students' participated in and their engagement ratings of the live webinars, $r_s(92) = 0.327$, $\boldsymbol{p = .001}$, as well as small positive correlations to their engagement ratings of the webinar recordings, $r_s(129) = 0.202$, $\boldsymbol{p = .021}$; video recordings of an instructor presenting to an audience in a lecture theatre, $r_s(128) = 0.235$, $\boldsymbol{p = .007}$; video recordings of an instructor presenting into a webcam, $r_s(128) = 0.260$, $\boldsymbol{p = .003}$. Therefore, an increase in the percentage of webinars that a student participated in was correlated to a small to moderate increase in the engagement ratings in the respective presentation format.

A Kruskal-Wallis H test and pairwise comparisons revealed statistically significant differences in median levels of engagement while participating in live webinars between the groups of students who participated in 25-50% of the live webinars compared to the group of students who attended 75-100% ($\boldsymbol{p = .009}$); while watching a webinar recording between the 0% group who attended none of the webinars and 75-100% group ($\boldsymbol{p = .050}$), and between the 25-50% and 75-100%

groups (***p* = .006**); while watching a video of the instructor presenting to an audience in a theatre between the 0% and the 75-100% groups (***p* = .050**), and between the 25-50% and 75-100% groups (***p* = .006**), and also while watching a video of the instructor presenting into a webcam between the 0% and 75-100% groups (***p* = .014**).

The Spearman's rank correlations showed a small to moderate increase in the engagement ratings for each of the four different presentation formats associated with the percentage of live webinars a had student participated in. That means an increase in webinar participation was associated with an increase in their engagement ratings. Framed in the negative perspective, there was a decrease in the engagement ratings associated with a decrease in the number of webinars a student participated in. This study cannot deduce a causative relationship between whether a student was disengaged because they did not (or could not) participate in a live webinar, or did whether they chose to not participate in a live webinar because they were generally a disengaged learner, or if it was due to some other causal factor(s) (Lumgair, 2017).

Live webinars were rated as the most engaging video lecture format, as judged by the 2015 students who participated in at least 25% of the webinars. The large class sizes in this study provided a sufficiently high sample size to make statistically significant findings. These findings were consistent with Holdhusen who compared four different blended delivery models for his engineering graphics course (Holdhusen, 2009). Unfortunately, Holdhusen's sample sizes were rather small at 10 to 23 students. He admitted that this did affect his ability to obtain statistically significant correlations. He still provided interesting and insightful comments comparing the effectiveness of four different delivery modes. His findings showed that purely asynchronous courses had higher attrition rates than those with a synchronous component. He surmised was due to the impersonal nature of asynchronous learning, a lack of collaboration with the instructor and fellow students.

The paper *Online and In-Seat Ethics Instruction: The View From Both Sides* (Leitch et al., 2012) compared an asynchronous online version of an engineering ethics course with the traditional in-person "in-seat" course results. The authors found, "since the students were taking the course in an asynchronous manner (working on assignments at their pace, not in real-time), collaboration is somewhat more difficult than when students see each other face-to-face" (Leitch et al., 2012). Again, this may be a contributing factor in the disengagement of the 0% group who attended none of the live webinars. "Break out rooms" was a webinar software feature utilized in the 2015 course to parse students into of small groups of 6-10 students to discuss case studies and collaborate on resolving ethical dilemmas. This was done intentionally and systematically to allow for virtual face-to-face collaboration and addressed that area for improvement implied in Leitch's study.

Effectiveness Ratings of Presentation Formats

The effectiveness of the course was studied from the perspectives of the TLAs, the assessments, and the learning outcomes. This section contains the results and discussion related to the TLAs and the presentation formats through which they were delivered. Students in 2015 were asked, "How effective was each format in you're learning the material? 1 being the least effective and 5 being the most effective." (Table 2) (Lumgair, 2017)

Table 2: Effectiveness Ratings of Each of the Presentation Formats

Presentation Format	n	Effectiveness (Weighted Average) scale of 1 to 5	Percentage of population that gave the format a "5 out of 5" effectiveness
Live Webinar	94	3.51	19.9%
Webinar Recording	133	3.32	14.3%
Video of Instructor presenting to audience in a theatre	133	3.11	9.02%
Video of Instructor presenting into a webcam	133	3.15	9.02%

Students who participated in the live webinars gave that format the highest weighted average effectiveness rating. Almost 20% of the respondents rated live webinars as a "5 out of 5" for effectiveness in their learning the material (Table 2).

Running a Spearman's rank-order correlation revealed that there was a strong positive correlation between the number of live webinars that students' participated in and how effective the live webinar format was to them, $r_s\,(127) = 0.506$, $\boldsymbol{p < .0005}$. There was also a small positive correlation between the number of live webinars that students' participated in and how effective the webinar recording format was to them, $r_s\,(129) = 0.194$, $\boldsymbol{p = .027}$, and a small positive correlation in and how effective the videos of the instructor presenting to an audience in a theatre format was to them, $r_s\,(129) = 0.192$, $\boldsymbol{p = .028}$.

A Kruskal-Wallis H test and pairwise comparisons showed statistically significant differences in median levels of effectiveness ratings of the live webinar presentation format between the 0% group that attended no live webinars and the group that attended 25-50% of the webinars **(p =0.049)**, the 0% and 75-100% groups **(p < .0005)**, and the 25-50% and 75-100% groups **(p < .0005)**. As well as statistically significant differences in median levels of effectiveness ratings of watching videos of the instructor presenting to an audience in a theatre between the 25-50% and 75-100% groups **(p = .010)** and for watching videos of the instructor presenting into a webcam between the 25-50% and 75-100% groups **(p = .035)**. All of these comparisons favoured the 75-100% group as rating effectiveness higher than the other groups (Lumgair, 2017).

To gain multiple perspectives on the effectiveness ratings of the four presentation formats, it was necessary to rank them for each of the webinar participation groups (by attending 0%, 25-50%, or 75-100% of the live webinars). The 75-100% group had the highest average mean effectiveness level felt across the four formats amongst the groups. The interpretation and discussion of effectiveness ratings parallels that of the engagement ratings. The perceived engagement and effectiveness of formats followed similar trends within the groups.

Qualitative Analysis of Comments About the Presentation Formats

Students in 2015 were asked to provide open-ended comments to this question:
"Please comment on why you chose the preferred format indicated in the previous question. What were the advantages and disadvantages of that method over the other methods?" (Tables 3 & 4) (all raw comments in Appendix D of Lumgair, 2017)

Student comments about the four presentation formats provided insights into what they enjoyed in each and what frustrated or bored them in each format. Technical issues were the main concern with live webinars. Boredom was cited as a disadvantage across all four formats.

Table 3: Number and Types of Comments About Presentation Formats (*n=133* total comments, some referred to more than one format)

Presentation format	**Positive comments**	**Negative comments**
Live webinar	66	16
Webinar recording	27	11
Video of instructor presenting to audience in lecture theatre	7	15
Video of instructor presenting into webcam	9	13
Reading textbook and avoiding videos	9	

Table 4: Summary of Representational Comments about Presentation Formats

Presentation Format	**Summary of Positive Comments** ***(n=118 total)***	**Summary of Negative Comments** ***(n=55 total)***
Live webinar ***(n=82)***	- Interact with instructor, TA, guest speaker, other students in chat - Questions addressed right away in the same session - Novelty - Instructor more passionate with an audience - could gauge the mood and respond - Focus on face, not PPT - Involved feeling - More engaging because had to listen (couldn't rewind) - Fun and engaging - Felt like one-on-one tutorial - Easy to follow: Had webcam of instructor and PowerPoint - No distractions from other students (compared to a theatre) - Engaging: talking right at me - Webinar Q/A and comment boxes made it easier to ask questions and have them answered without interrupting - Could watch at home - Students' were more inclined to get distracted when not live - Kept students from procrastinating - Felt obligated to watch webinars because I feel obligated to go to lectures	- Webinar crashed – frustrating, so gave up on them - Lag - Too much down time figuring out technology or glitches – disengaging - Couldn't attend due to time conflicts - Do not provide the same level of engagement as an in-class lecture - Pace can be too quick - Inappropriate chat conversations happening between students - Less expressive because can only see face, not entire body

Presentation Format	**Summary of Positive Comments** ***(n=118 total)***	**Summary of Negative Comments** ***(n=55 total)***
Webinar recording ***(n=38)***	- Convenience: fit into schedule - Watch at own pace - Pause, rewind, take notes - Fast-forward through sections - Could still see chat and comments that had happened - Can watch at 1.8X or 2X speed - No crashing or technical difficulties	- Not real-time, do not have the same sense of engagement - Mind wandered off, had to re-watch - Dulled down after the fact - Boring
Video of instructor presenting to audience in lecture theatre (professional video & audio) ***(n=22)***	- Questions asked by other students in the theatres were addressed more effectively (all were addressed and questions were asked one by one, rather than all at once on a chaotic scrolling live chat) - More interesting because the presenter would be moving and expressing themselves with more than just their face. Advantages: more engaging, easier to stay focused on the topic, easier to "connect" with the presenter.	- Couldn't see PPT slides on screen, needed another window open – harder to follow along - Poor video quality, needed editing - Impersonal - Webcam more engaging than theatre - Boring - Presentation may not have felt as direct. May not have been able to see a screen or other visuals that the presenter was using.
Video of instructor presenting into webcam ***(n=22)***	- PPT slides easily seen next to webcam video of instructor - Instructor stayed on topic, didn't go on tangents (no questions) - Ease of access	- Pace felt artificial - Instructor read off the PowerPoint slides word for word. - Boring
Reading textbook and avoiding videos ***(n=9)***	- I preferred reading the textbook and only watched the guest speaker lectures. This allowed me to go at my own pace and re-read all of the important content without having to rewind a video.	

Effectiveness of Assessments

In 2014, the students were issued four online quizzes worth 50% of their final grade. While there were only three online quizzes worth 44% of their final grade in 2015. These quizzes tested the theory and case-studies taught in the lectures and as written in the required course textbook *Canadian Professional Engineering and Geoscience Practice and Ethics, 5th ed.* (Andrews, 2014). Concepts and lessons learned from guest lecturers were also tested. This textbook was selected for the course because it is required reading for an Engineering-In-Training (E.I.T.) to pass the National Professional Practice Exam (NPPE) in order to become a Professional Engineer (P.Eng) in Canada. (Lumgair, 2017)

Multiple-choice, multiple selection and matching style questions were used because they could be automatically marked by the Learning Management System (LMS) and entered into the LMS grade book without any human labour. The time allocated to write each quiz was 1.2 minutes per question, which was the same as the NPPE. Quizzes were open-book, open-notes but were to be completed individually. It was impossible to supervise that the tests were indeed completed individually, and some students were commented about cheating in their surveys. The time window to write a quiz was 48 hours. Students could start their quiz at any time in that window. After the testing time window had expired, the instructor allowed students to review which questions they got wrong on the test.

For the online quizzes the average grades were similar from 2014 to 2015 (Table 5). However the standard deviation was much less in 2015.

Table 5: Online Quiz Grades by Year

	2014				2015		
	N	Mean	Std. Deviation		N	Mean	Std. Deviation
Quiz1	411	82.9	11.5	Quiz1	467	88.2	9.51
Quiz2	411	83.1	13.3	Quiz2	468	89.8	7.27
Quiz3	410	88.7	12.3	Quiz3	464	89.2	6.65
Quiz4	411	90.1	12.6				

In 2014 & 2015 students were asked, "How effective were the online quizzes at assessing your knowledge and understanding of the [course] learning outcomes?" on a 5 point Likert scale from "very ineffective" to "very effective". In 2014, the mean effectiveness score was 3.52 out of 5, which is above "neutral" and closer to "effective". The median and mode were 4, or "effective". Similarly, in 2015 the mean effectiveness score was 3.72 out of 5. The median and mode were also 4, or "effective". In both years approximately two-thirds of the students judged the online quizzes to be "effective" or "very effective".

A Spearman's rank-order correlation revealed a small positive correlation between the number of live webinars students participated in and the perceived effectiveness of the online quizzes at assessing students' knowledge and understanding of the learning outcomes, $r_s(123) = 0.218$, $\boldsymbol{p = .015}$.

A Kruskal-Wallis H test and pairwise comparisons revealed statistically significant differences in median levels of perception of the effectiveness of the online quizzes at assessing students' knowledge and understanding of the learning outcomes between the 0% group that attended no webinars and the 75-100% group **(p = .035)**.

The effectiveness of issuing a few quizzes worth a smaller amount of the final grade vs. one or two large summative tests was been studied with practicing engineers at Boeing Inc. (Lawton et al., 2012). At Boeing engineers taking a new version of a long running online course experienced "a significant overall improvement in learning and learner attitude in the treatment course… [that] used integrated formative assessment as opposed to a more extensive reliance on summative assessments in the control course.". This assessment strategy had also been found to be beneficial for the online flipped classroom delivery of mechanical engineering courses (Hugo & Brennan, 2016).

While it is possible to issue many small assessments in a traditional in-person course they would all need to be hand-marked by TAs (unless they were completed on a computer during class time). Online quizzes can be set up in an LMS to provide a range of input variables for calculation questions. Each student is issued a random set of input variables, and the LMS can automatically grade their final answer based on those particular variables. This is an example of were online learning technology can increase the efficiency of grading and thereby allow for more frequent assessments with the same set of TA resources.

The final question of the survey said, "(Optional and anonymous, you will not be questioned further on this) Were you aware of anyone copying / cheating on the online quizzes or assignments? How were they copying / cheating? In your perception how many people do you think copying / cheated?" Out of the 49 comments left by respondents in 2015, 26 of them described cheating that they were aware of or outright admitted to cheating and even provided justifications. Other students could not say they were personally aware of cheating. Methods of cheating included: several students taking the online quiz together at the same time, one student writing the quiz then helping their friends write it, students logging into the LMS to write a friend's quiz on their behalf, screenshots of quiz questions being shared in private Facebook Groups amongst students and more.

Online quizzes cannot be properly supervised outside of an approved testing center on campus or a third-party company that performs that service. In the future, the instructor would no longer use unsupervised online quizzes as a gradable component. However, they could be used for practice in preparation for a supervised test.

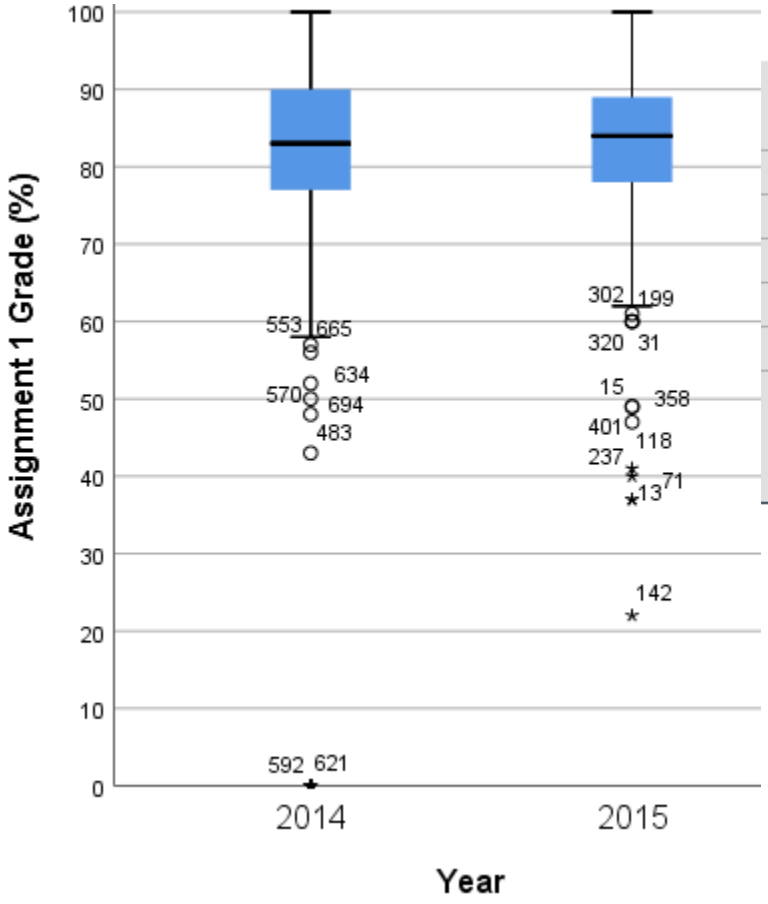
Assignment 1: Written Case-Study Analysis

The first assignment was a 2-page written case study analysis of an industrial disaster. Students could choose to analyze one of the four case-studies pre-selected by the instructor. Topics were changed from year to year to reduce the risk of plagiarism. The students' analysis needed to focus on the root cause of the incident, the engineer's responsibilities and decisions, the health, safety and environmental impacts of the disaster, as well as the resulting legal consequences and regulatory changes. This was a qualitative evaluation of the "professionalism" ABET student

outcome. The assignment was worth 25% of the final grade, and was to be submitted electronically to the LMS assignment drop box before the deadline.

Approximately 75% of respondents in 2014 and 72% in 2015 rated assignment 1 to be "effective" or "very effective" at assessing the outcome of professionalism. Only 7% and 12% judged it to be "ineffective" or "very ineffective" in 2014 (*n=152*) and 2015 (*n=126*) respectively. The average grade and mark distributions for assignment 1 were similar from 2014 to 2015 (Figure 3 and Table 6). The standard deviation in 2015 was 7% lower than 2014.

Figure 3 and Table 6: Assignment 1 Grades by Year



Assignment1		2014	2015
N	Valid	411	467
	Missing	0	2
Mean		81.2	82.8
Median		83.0	84.0
Std. Deviation		16.5	9.77
Minimum		.00	22.0
Maximum		100.00	100.00
Percentiles	25	77.0	78.0
	50	83.0	84.0
	75	90.0	89.0

Assignment 2: Video Presentation of Resolving an Ethical Dilemma

In assignment 2 students were to video record themselves delivering an oral presentation on how they would resolve a given ethical dilemma. Students selected one of four ethical dilemmas chosen from a resource developed by The Royal Academy of Engineering entitled *Engineering ethics in practice: a guide for engineers* (2011). Students were to resolve the ethical dilemma by, "applying the [six step] design process to ethical problems" outlined in the course textbook (Andrews, 2014). It was worth 25% of their final grade. A project like assignment 2 was identified in the literature as an area for improvement in engineering ethics education (Itani, 2013).

Students could work individually or in pairs and the videos were limited to 10 or 12 minutes, respectively. Students were not required to show their faces and could speak over a PowerPoint or other creative animation. The assignment document was 17-pages in length including very detailed instructions, a detailed marking rubric, one page of background information for each of the four dilemmas, video equipment to consider, public speaking tips, technical details on how to format the video file and the estimated (lengthy) time it may take to upload the video to the LMS dropbox. As well as a process to follow if they had any questions: re-read the assignment, then check the FAQ in the discussion forum, watch a video of the instructor answering students' questions about the assignment the previous year, then finally email the instructor. A grade appeal process was also outlined if the student did not agree with the TA's evaluation.

In the survey, students were asked, "How effective was assignment #2, the video oral presentation on an ethical dilemma at assessing your knowledge and understanding of Ethics and Equity as defined by the CEAB as, 'an ability to apply professional ethics, accountability and equity.'?" (Lumgair, 2017)

In 2015 over 67% of the students found assignment 2 to be "effective" (49%) or "very effective (18%) in assessing the outcome of ethics and equity (*n=126)*. While 13% found it "ineffective" and 6% deemed it "very ineffective". This resulted in an average effectiveness rating of 3.6 out of 5, with 3 being "neutral" and 4 being "effective". The median and mode were 4, which was "effective". These ratings were an improvement over the 2014 survey results where 48% found it "effective" or "very effective" and 28% found it "ineffective" or "very ineffective". The average effectiveness rating of 3.2 out of 5, with 3 being a "neutral" (*n=152*).

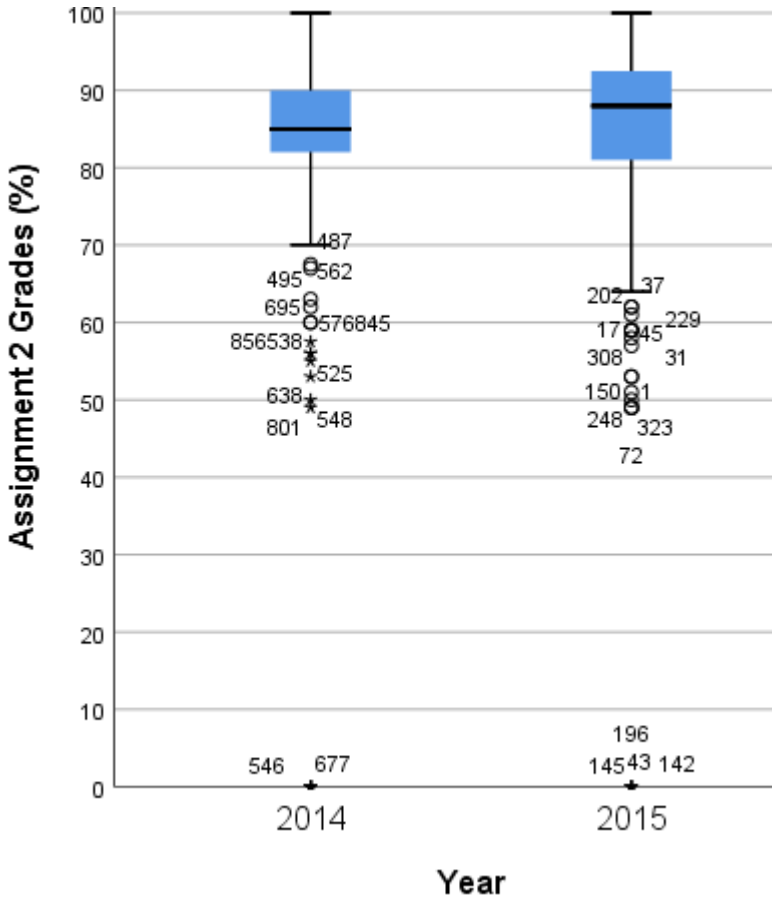
The following two videos were exceptional examples of student work on assignment 2 and both received 100% in 2014. They were highly entertaining and creative while hitting all the key points. Students did not need to put in any video post-production to get an "A", but this showed what was possible. Both pairs of students gave the author written permission via e-mail to share their videos. These two example videos were included in the assignment document in the second year of the course. That additional clarity may have been one of the reasons more students found the assessment effective.

Daniel Lee and Eric Lim: https://www.youtube.com/watch?v=dI_2UWNAvcc
Esha Saxena and Mahfam Vakili: https://www.youtube.com/watch?v=0-cdGva6nM4

For large classes, open-ended qualitative assessments required assignment documents that limited topic choices to a few options, and included detailed instructions on what the outcomes and expectations were. Assignment documents needed to include the marking rubric and grade appeal procedure. The instructor provided two ways to submit the assignment, the LMS and DropBox.com as an alternative if students had technical issues uploading to the LMS.

For assignment 2 the average grade and mark distributions were similar from 2014 to 2015 (Figure 4 and Table 7).

Figure 4 and Table 7: Assignment 2 Grades by Year



Assignment2		2014	2015
N	Valid	409	468
	Missing	2	1
Mean		84.1	84.9
Median		85.0	88.0
Std. Deviation		14.4	13.2
Minimum		.00	.00
Maximum		100.00	100.00
Percentiles	25	82.0	81.0
	50	85.0	88.0
	75	90.0	92.7

From the video submissions it was seen that some students very much enjoyed assignment 2 and went above and beyond with their creativity and post-production effort. Other students were put outside of their comfort zone by needing to deliver an oral presentation. While others had become frustrated by hassles with technology from recording the video, editing it, and/or issues uploading the video to the LMS or needing to upload it to the alternative destination on Dropbox.com. Some students were so used to writing long summative assessments that this change in assessment format perturbed them. Overall, assignment 2 was effective for having students demonstrate their level of competency with respect to the graduate attribute of ethics and equity as well as their oral communications skills.

There was a subjective component to these qualitative assessments in terms of how the student interpreted what is expected, how they presented their findings, and the assessor's evaluation of their work. The approach of applying the design process to ethical problems was very practical because it utilized a problem-solving process familiar to engineering students to navigate the complexities of an ethical dilemma (Andrews, 2014). Ultimately, it guided students through a process whereby they needed to employ the higher-levels of understanding in Bloom's

taxonomy: Apply, Analyze, Evaluate / Judge, and Create by making a decision on what was to be done (Anderson & Krathwohl, 2001).

The design process approach also allowed for the development of a logical marking rubric. This helped to reduce some of the subjective bias of the TAs who graded the videos and provided better consistency in marking across the hundreds of submissions. When a student disagreed with the TAs mark on their assignment they had the opportunity to appeal the grade. The instructor would then use the same rubric to re-assess the assignment. In a few cased the instructor identified penalties that had not been deducted by the TA according to the rubric. The rubric helped justify deductions.

Effectiveness of Achieving Student Outcomes

The effectiveness of the course ultimately relied on the students achieving the ABET student outcomes, which were used in the instructional design of the course learning outcomes. Students were presented the CEAB graduate attributes for professional skills and asked, "The online learning and video lectures in this course were an effective way to learn and achieve the following CEAB (Canadian Engineering Accreditation Board's) graduate outcomes: [select all that apply]" (Table 8) (Lumgair, 2017).

Table 8: Percentage of students who indicated that they had achieved the "professional skills" Canadian Engineering Accreditation Board graduate outcomes

CEAB graduate attribute	2014 students' response (*n=152*)	2015 students' response (*n=126*)
Professionalism	87%	86%
Ethics and Equity	86%	90%
Impact of engineering on society and the environment	85%	79%
Written Communication	55%	70%
Oral Communication	63%	68%
Life-long learning	No survey question	63%

The majority of the student respondents in both years found the online courses effective in their achieving the professional skills CEAB graduate attributes (and equivalent ABET outcomes) (Table 8).

A Spearman's rank-order correlation was run to assess the relationship between the percentage of live webinars students participated in (2015) and perceived effectiveness of this online course in their achieving the various CEAB attributes. There was a small positive correlation between the percentage of live webinars students participated in and effectiveness ratings of the 2015 course in their achieving these CEAB graduate attributes: Impact of engineering on society and the environment, $r_s\ (144) = .164$, $\mathbf{p = .048}$, and Life-long learning, $r_s\ (144) = .280$, $\mathbf{p < .0005}$. A Kruskal-Wallis H test and pairwise comparisons revealed statistically significant differences in median levels of students who said they achieved the CEAB attribute of "lifelong learning

between the 0% group that attended no webinars and 75-100% group (***p = .004***) and between the 25-50% and 75-100% groups (***p = .004***).

Therefore, an increase in synchronous webinar participation was correlated with a small increase in a student self-assessing that they had achieved the graduate attributes related to life-long learning and the impact of engineering decision on society and the environment.

The attributes of professionalism and ethics & equity were recognized by over 86% of students as being effectively achieved in either of the online courses. The attribute of life-long learning was indicated by only 63% of the students as being effectively learned in the 2015 course. This may be linked to the Spearman's rank correlation that showed that there was a small correlation between the number of live webinars a student participated in and their perception that the life-long learning attribute was achieved in this course. The students who attended none of the live webinars had a mean effectiveness score of 41% for the life-long learning attribute compared to 70% for the 25-50% group and 75% effectiveness score from the group who attended 75-100% of the webinars.

In both years of the course, the student survey included a second series of self-efficacy questions that was asked of all of the fourth-year engineering students at the University of Calgary. Students were asked how confident they were in their ability to perform a certain task that an engineer could do in their daily work. The phrasing of the self-efficacy question was, "for each statement below, please indicate how confident you are that you have the capability to perform each task listed below, if you were to enter the workforce today. How confident are you in your ability to:_____". Eleven of the 38 questions focused on the professional skills graduate attributes and are summarized in the Table 9.

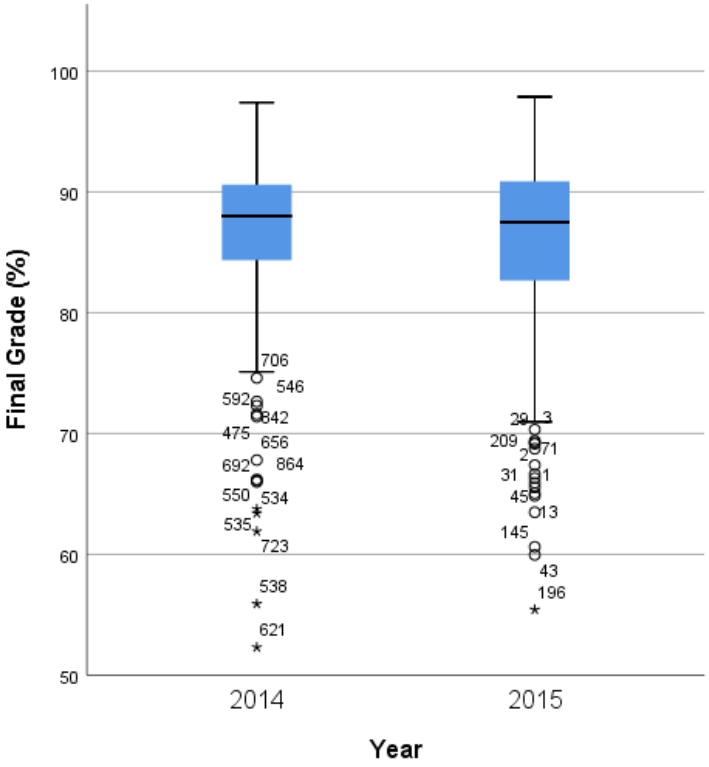
The results of the 11 self-efficacy questions revealed that the average confidence level across all of the professional skills graduate attributes was over 75% confidence. In their own eyes, the majority of students had learned and achieved the professional skills graduate attributes. There was a slight year-over-year increase in their confidence in engineering professionalism and ethics tasks.

Table 9: Self-Efficacy Ratings of Confidence in One's Ability to Perform Tasks Related to the Professionalism Skills Graduate Attributes (Scale from 0% [no confidence] to 100% [total confidence])

	Profession-alism	**Ethics & Equity**	**Life-long Learning**	**Impact of Engineer-ing on Society**	**Written Communi-cation**	**Oral Communi-cation**
Average Mean 2014 (*n=145*)	79%	82%	Not asked	77%	77%	78%
Average Mean 2015 (*n=121*)	80%	87%	81%	79%	75%	79%

The average final grades and mark distributions were very similar from 2014 to 2015 (Figure 5 and Table 10).

Figure 5 and Table 10: Final grades by year



FinalGrade		2014	2015
N	Valid	411	468
	Missing	0	1
Mean		86.2	85.7
Median		88.0	87.4
Std. Deviation		8.6	7.6
Minimum		21.8	37.0
Maximum		97.4	97.8
Percentiles	25	84.3	82.6
	50	88.0	87.4
	75	90.6	90.8

Figure 5 and Table 10 showed that at the end of the day, students in the webinar-based blended learning class performed as well as the students in the in-person lecture-based blended learning class. Therefore, it can be said that synchronous webinars were effective in replacing in-person lectures as part of a blended learning online course.

Conclusions and Recommendations

Essentially the same course content on engineering ethics and professional responsibilities was taught two years in a row. In the first year a blended online learning model was used that included traditional in-person lectures on campus and asynchronous videos recordings, textbook readings and a discussion forum. The second year the course was taught using synchronous live webinars in place of the in-person lectures. Both years had large class sizes of 411 and 468 students, respectively.

The results of both sets of student surveys about the effectiveness of the assessments were very similar in many respects. The grades of the individual assessments, the final grades and the distribution of all of the above, were very similar as well.

The data showed that by offering live webinars as a learning method 10% more students took the opportunity to interact live with the instructor and peers when compared with the attendance of

in-person lectures in a theatre. Approximately 20% of the survey respondents indicated they had attended 75-100% of the in-person lectures and 6% watched them over the livestream. While, nearly 36% of the 2015 survey respondents said that they had attended 75-100% of the live webinars. The means that 10% more students chose to attend 75%-100% of the synchronous lectures when they were offered as live webinars instead of in-person lectures (combined with a one-way livestream).

When live webinars were offered as a synchronous learning method, most students picked that as their preferred presentation format. This was contrasted with the 2014 results where the vast majority of student preferred watching asynchronous videos over the in-person lectures (or livestream).

The student survey in the second year (2015) included additional questions to gauge which presentation format the students found the most engaging and most effective in learning the outcomes. An increase in the number of webinars that students participated in was correlated to a small increase in student ratings of engagement across all four presentation styles (that was statistically significant). There were differences in median ratings of engagement across all four presentation formats between the 0% group that attended none of the live webinars and the group that attended 75-100% of the webinars (favouring the 75-100% group). The median ratings of the effectiveness of live webinars were the highest amongst the four presentation formats.

Overall, replacing traditional in-person lectures with synchronous webinars was a success in terms of similar effectiveness ratings, average grades and grade distribution.

For large classes, open-ended qualitative assessments required assignment documents that limited topic choices to a few options and included detailed instructions on what the outcomes and expectations were. Assignment documents needed to include the marking rubric and grade appeal procedure. The instructor provided two ways to submit the assignment, the LMS and DropBox.com as an alternative if students had technical issues uploading to the LMS.

It is important to note that while the format of online learning allows for virtually unlimited enrollment, there is a hard cost to the labour required to mark qualitative assignments that maintain the rigorous quality required by accreditation standards. This includes the dozens of hours the Teaching Assistants spend marking and the time the instructor required to reply to innumerable emails asking questions about the assignment, re-assessing assignments where the grade has been appealed, and supervision of TAs to ensure consistency in marking. These challenges and findings were consistent with the authors' of *The ABET "Professional Skills" – Can They Be Taught? Can They Be Assessed?"* (Shuman et al., 2005).

Delivering the lectures via webinar and having the students video their presentations for assignment 2 did alleviate the infrastructure burden on the university's classrooms. However, it did not alleviate the burden of marking so many videos. Each video was 10 or 12 minutes in length. On top of that, it took time to find the video, stop and start the video to catch key points or confirm the lack thereof, completing the rubric, entering the grade and rubric comments into the LMS. Combined it took on average 15 minutes to assess each video submission. The second assignment required approximately 15 minutes to watch and mark. Many students decided to

work in pairs so there were approximately 250 videos, which would have taken 3750 minutes or 62.5 hours of solid video watching and marking.

Likewise, assignment 1, the 2-page written case study analysis, took approximately 12 minutes to mark. There were 469 students enrolled in 2015, so that meant approximately 5628 minutes or 93.8 hours of marking. Five separate TA contracts at 68 hours each were required to handle all of the job responsibilities for this course. That was a theoretical total of 340 hours of work or 8.5 weeks of full-time work. It was found that one TA contract of 68 hours was required for every 100 students enrolled in the course.

Facilitating and administering these large online classes placed additional burdens on the instructor. Students usually contacted the instructor individually via email. After responding to an email query the instructor would place that question and answer in the FAQ section of the discussion forum and direct similar email queries to the FAQ.

After a webinar or in-person lecture was video recorded it took the instructor an equivalent amount of time to perform the video or webinar post-production and upload the recording to the LMS. For every 200 students enrolled in a large online class it required approximately the same amount of instructor loading time as teaching and administering one semester-long engineering course. For example, if an online course has 400 students, then the instructor needs to be loaded the same as two in-person courses taught in a lecture theatre (Lumgair, 2017).

The maximum enrolment of students into an online course for engineering ethics and professional skills development were found to ultimately be constrained by the nature of qualitative assessment and the human labour required to evaluate the students level of understanding. This may not be the case where purely mathematical assessments can be programmed into the LMS' online testing software, where it is possible to randomize the input variables each student receives in their unique problem to solve. These types of questions can be graded automatically according to a rubric. However, this level of automation is not possible with qualitative assessment at this time.

In conclusion, yes, engineering ethics and professional skills learning outcomes can be effectively taught and assessed using a blend of synchronous webinars and asynchronous learning methods in a large online class. When compared to a blend of traditional in-person classes and video recordings, the webinar class performed equally well. Either blend of learning methods can be utilized successfully in an online course without sacrificing the quality of teaching and learning or the rigour of assessment of a traditional in-person class. The caveat is that there needs to be qualitative assessments that require students to demonstrate a high-level understanding and ability to apply these skills to open-ended problems within the context of engineering practice. Furthermore, to ensure a program and course assessment meet the accreditation standards for quality teaching and learning the instructor and teaching assistants require loading hours and resources proportionate to the number of students enrolled in the course.

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