Assessment of Instructional Modalities for an Electromagnetics Course

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Abstract

Due to the COVID-19 outbreak, our electromagnetics course was offered in three different modalities in three different years. The course was offered in the face-to-face modality in spring 2019. It was offered partially face-to-face and partially online in spring 2020 due to the pandemic. It was offered completely online in spring 2021 due to the pandemic again. The learning objectives, topics, and course load remained essentially the same in those three offerings. The instructor was the same also. The difference was in the mode of delivery and its associated course management. The same university-administered student evaluation of the course was conducted in every offering. The evaluation included five indicators that were relevant to the effectiveness of instruction. The finding was that the effectiveness of instruction in those online offerings during the pandemic was kept at the same level as the face-to-face offering based on the data collected.

Keywords

Remote instruction, face-to-face instruction, video lectures, distance learning, assessment

Introduction

The COVID-19 pandemic has upended the conventional approach of face-to-face instruction and inspired alternative approaches for engineering education. It has also fostered certain instructional modalities, for example, the online approach for engineering education. The pandemic has inadvertently provided a fitting opportunity for comparing the effectiveness of the traditional face-to-face modality to that of the online approach in some of our engineering courses. We investigated the effectiveness of these modalities conducted in our junior level electromagnetics course, which is a core course in our electrical engineering curriculum. The course was offered as a face-to-face course in spring 2019, as a partially face-to-face and partially online course in spring 2020 due to the pandemic, and as a completely online course in spring 2021 due to again the pandemic. The learning objectives, topics, and course load remained essentially the same in those three offerings. But the mode of delivery and the associated management of the course were different. It was the same instructor teaching this course in those three offerings. University-administered student evaluations were conducted in those three offerings. The evaluation included the effectiveness of instruction. Among the indicators for evaluating the effectiveness of instructions were 1) communication of ideas and information effectively, 2) explanation of complex concepts and ideas clearly, 3) stimulation of critical and creative thinking, 4) well-organized and provided a framework conducive to learning, and 5) whether the course was set in high standards and challenging. The results are presented in this paper.

In the rest of this section, the electromagnetics course under consideration is described briefly. The three different instructional approaches in those three years will be discussed in the next section. The student evaluations and the findings will be provided in the section following. Concluding remarks will be offered in the last section.

The electromagnetics course is a junior level core course that covers transmission line theory, electrostatics, magnetostatics, and time-varying electromagnetic fields. Vector calculus was used heavily for solving the electromagnetics problems in this course. The course contents are organized into seven modules. The topics in the modules are summarized as follows:

- Module 1. Review of traveling waves, complex numbers and phasors.
- Module 2. Transmission lines: lumped-element model, transmission-line equations, wave propagation, reflection coefficient, standing waves, wave impedance, and Smith chart.
- Module 3. Vector calculus: orthogonal coordinate systems and their transformations; algebraic vector operations; gradient, divergence, curl, and Laplacian operators; divergence and Stokes theorems.
- Module 4. Electrostatics: Coulomb's law and its applications, Gauss's law and its applications, electric field, electric scalar potential, and current density.
- Module 5. Magnetostatics: magnetic force and torque, Biot-Savart law and Ampere's law and their applications.
- Module 6. Time-varying electromagnetic fields: Faraday's law, moving conductor/loop in static and time-varying magnetic fields, displacement current, and Maxwell equations in time and phasor domains
- Module 7. Uniform plane-wave equations and their solutions. Relationship between electric and magnetic fields in uniform plane waves.

Instructional approaches

In spring 2019, the course was conducted in the face-to-face modality on campus inside a classroom. It was instructor-centered. The instructor taught the course materials to the students during class time. Students had opportunities to interact with the instructor and other students by asking questions and by expressing their comments. All the topics specified in the course syllabus were covered in the classroom. Students were informed of the course expectation, learning objectives, topics, reading assignments, and homework assignments in the start of the semester. Exams were conducted in the classroom and proctored by the instructor. Student evaluation was conducted at the end of the course and was administered by the university without the instructor.

In spring 2020, the course was taught in the face-to-face modality on campus inside a classroom for ten weeks before the spring break. After the spring break, due to the pandemic the course was taught online for the rest of the semester (about five weeks). New instructional video lectures were prepared weekly for the instructions in those five weeks. The development of these video

lectures was discussed before[1]. These video lectures were uploaded into Canvas Studio. Canvas is a learning management system. Studio is an integrated video sharing platform that allows instructors and students to share video contents in Canvas. Students streamed the lecture videos from Canvas Studio to themselves for learning at either the regular class time or at other times matching their schedules. Weekly announcements were sent to students informing them what to do each week in those five weeks. Twenty-four lecture videos were produced in those five weeks of online instruction. These 24 videos covered the last two and a half modules of the electromagnetics course. The average length of the videos was approximately 30 minutes. The total size was approximately 12 GB. The same course contents as in the spring 2019 offering were taught in this semester. The exams were at the same level. Student evaluation was also conducted at the end of the semester.

In Spring 2021, the course was taught online in the entire semester. Like the last five weeks of the spring 2020 semester, lecture videos were prepared weekly and uploaded to Canvas Studio for the students to stream to themselves at their own schedules. The lecture videos were content-focused. The topics specified in each of the modules were covered in the lecture videos. A total of 82 videos was produced for the entire semester. The average length was about 32 minutes. The total size was 38 GB. Weekly announcements were sent to the students informing them of the particular lecture videos to view for the week, the reading assignments, the homework problems, and the ways to get help from the instructor. The reading assignments matched the contents of the lecture videos and offered extra materials for those students interested in learning more about the topics discussed in the videos. The videos also taught problem solving skills by examples. That helped the students solving the homework problems. Examinations were conducted by Honorlock, an online examination proctoring service. The instructor was available to the students during the Honorlock periods. The same course contents as in the previous two offerings were taught in this semester. The exams were at the same level like before. Student evaluation was also conducted at the end of the semester.

The instructor used a Samsung tablet with a stylus (S-Pen), a Samsung notetaking app (S-Note), and an Android screen recording app (xRecorder) in the production of the lecture videos. The instructor was familiar with those tools at the start of the spring 2021 semester because he had used the same tools in the prior semesters during the pandemic. The instructor was aware of other apps, for examples, Microsoft OneNote, Evernote, Surface tablets, etc., that could be helpful. Those tools were not used because the instructor was more accustomed to the former set of tools.

The instructor's experience was that the Samsung tablet, the S-Pen and S-Note facilitated a smooth enough process for presenting the lecture materials and the step-by-step problem solving procedures. Also, the xRecorder app was an easy-to-use screen capture tool for recording the video lectures in mp4 format. Video lectures are one of the methods for the delivery of education online. Some of the studies[2,3,4,5] reflected the benefits of that method.

Assessment

Our university administers instructional satisfaction surveys to our students every semester. These surveys are conducted without the involvement of the instructors. These instructional satisfaction surveys include five assessment items pertaining to the effectiveness of instruction.

These five assessment items are 1) the communication of ideas and information effectively, 2) explanation of complex concepts and ideas clearly, 3) stimulation of critical and creative thinking, 4) well-organized and provided a framework conducive to learning, and 5) whether the course was set in high standards and challenging. The results of these five assessment items for those three offerings will reflect the level of student satisfaction for those three different modalities of instruction described in the last section. The assessment results for spring 2019, spring 2020, and spring 2021 are summarized in Table 1.

Table 1: Results of the assessment

Term	Spring 2019	Spring 2020	Spring 2021
Modality	Entirely F2F	10 weeks of F2F and 5 weeks of online	Entirely online
Number of students responded to the survey and enrollment	10 out of 48	10 out of 37	15 out of 32
Scale	From 0 to 5	From 0 to 5	From 0 to 5
Communication of ideas and information effectively	4.33	4.4	4.60
Explanation of complex concepts and ideas clearly	4.50	4.50	4.53
Well-organized and provided a framework conducive to learning	4.56	4.50	4.53
Stimulated critical and creative thinking	4.44	4.20	4.27
Set high standards that challenged students in the course	4.56	4.70	4.80

The numerical scores in those three years were close to one another. There was no single assessment item in any of the three offerings significantly higher than the other offerings. Considering that the contents of the course, the learning objectives, and the course load remained essentially the same, the exams were at the same level, and the instructor was the same, the effectiveness of the last offering in the online instructional modality was about the same as the other two.

To investigate whether the different instructional modalities would affect the instructor's rating, the rating data from those three years were compared and are shown in Table 2 below. It is noticed from the table that the instructor's rating increased every year in those three years but the increase was small and not significant.

Concluding Remarks

The three different ways of delivering the course to the students in those three offerings were described. In each offering, the learning objectives, the topics, and the course load were kept essentially the same. The exam problems were at the same level as those for the other offerings. The results of the assessment items for the effectiveness of instruction in one offering were

basically the same as the other two offerings. This indicates that the instructional modalities did not influence the student satisfaction in a significant way for this electromagnetics course. Further investigation will be conducted to find out if same finding occurs in other courses.

Table 2: Instructor's ratings

Course: Electromagnetic Field Applications	Spring 2019 (entirely F2F)	Spring 2020 (10 weeks of F2F and 5 weeks of online)	Spring 2021 (entirely online)
Number of students responded to the survey and enrollment	10 out of 48	10 out of 37	15 out of 32
Scale	From 0 to 5	From 0 to 5	From 0 to 5
Overall rating of instructor	4.22	4.30	4.38

References

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