Teaching Thermodynamics via Site-Synchronous Technology

Priya T. Goeser
Professor, Department of Mechanical Engineering, Georgia Southern University

Abstract

A consequence of the consolidation of two or more universities is the unequal allocation of resources and student enrollment. Administrators and faculty then must pursue non-traditional delivery formats for several courses. The consolidation of Armstrong State University and Georgia Southern University resulted in a similar situation where one campus has a much lower enrollment resulting in several courses being offered via site-synchronous technology. This technology allows the interaction between the instructor and students in real time emulating that in a traditional face-to-face classroom, with the instructor and students located in remote sites. Thermodynamics was one of the courses selected to be offered in this format in Fall 2019. This paper presents an overview of this delivery method including the advantages and disadvantages from an instructor's perspective and a student's perspective. While no direct conclusions can be drawn from this preliminary study, feasible suggestions are recommended for improving student's learning experience and performance.

Keywords

Thermodynamics via distance learning, distance learning, synchronous vs asynchronous teaching, site synchronous learning

Introduction and Motivation

Thermodynamics is a required course in all mechanical engineering curriculums and serves as an elective course for electrical and computer engineering students. The primary topics covered in the course are: the conservation of mass and energy in systems, properties of pure substances, entropy, gas and vapor cycles. The course is a junior level student's first introduction to multiple abstract concepts and terms used in conjunction with complex problem solving. Hence, smaller class sizes with a traditional face-to-face setting are strongly recommended. In the recent past however, the lack of ample faculty to teach the course across campuses has forced administrators and faculty to pursue other delivery formats.

Armstrong State University was recently consolidated with Georgia Southern University and now exists as a single university with multiple campuses. While most of the engineering students are on the main campus, a small cohort of freshmen-junior level students choose to complete their first two-three years of the engineering curriculum at the Armstrong campus. In order to meet the needs of both student bodies, a set of classrooms were converted to site-synchronous classrooms on all campuses in Summer 2019. This technology allows faculty to teach synchronous courses across multiple campuses in real time.

In Fall 2019, Thermodynamics was one of the courses selected to be taught as a site-synchronous course. The author is currently teaching this course and exploring the best pedagogical practices

for using this technology effectively. The author has taught the same course in a traditional face-to-face environment for the past ten years. This study does a comparison of the two delivery methods from an instructor's perspective and from a student's perspective. While no direct conclusions are drawn, feasible suggestions are recommended for improving the student's learning experience and performance.

The use of similar technology has become more popular in the recent past with the growth of online courses, distance learning courses and hybrid courses[1-5]. Studies show that the various delivery formats do not result in different student learning outcomes as compared with those in a traditional face-to-face course [6-8].

The following sections present an overview of the technology used, the teaching pedagogy, assessment based on student surveys including comments from the instructor's perspective, and a few concluding remarks with an outline of future work.

The Site-Synchronous Technology

The site-synchronous technology was made feasible by Cisco's Telepresence Codec system[9]. The system connects two or more classrooms (sites) virtually in real-time. The broadcaster site is considered the local site and is usually the classroom with the instructor. The partner site is the remote site and is the classroom on the remote campus. Both sites are equipped with Codec cameras in the front and back of the rooms, large TV monitors/screens in the front and back of the rooms and ceiling mounted microphones. A sample set up for the broadcaster (local) site is shown in Figure 1 and that for the partner (remote) site is shown in Figure 2 [10]. Note that either site can play the role of the broadcaster or partner and the switch may be done in real time during a class session if needed. The instructor station on both sites is equipped with a Creston panel, a PC and a document camera. The PC's screen (example: PowerPoint slides) or the document camera can be shared and projected at both sites simultaneously.

At the beginning of class, the instructor from the broadcaster site calls (connects to) the partner site using the Creston panel to set up the site-synchronization session. This takes only a few seconds to complete. Once the class is in session, the instructor teaches in manner similar to a traditional face-to-face classroom. The instructor's image is projected on one of the TV monitor's in the remote site in real time and his/her notes/desktop are projected on the second monitor as shown in Figure 3. The instructor is also able to see and interact with students in the remote site via the monitor at the back of the classroom in the local site. Students in the local site can interact with the instructor as in a traditional face-to-face classroom, see the instructor's notes/desktop projected on the TV monitor as well as interact with the students in the remote site via the second TV monitor. A simple setting on the Creston panel allows the instructor to change the mode from a presenter to a discussion mode. This allows the camera to track students who are talking and allow for a discussion between students in one site or between the two sites. The ceiling mounted microphones capture the audio from the students.

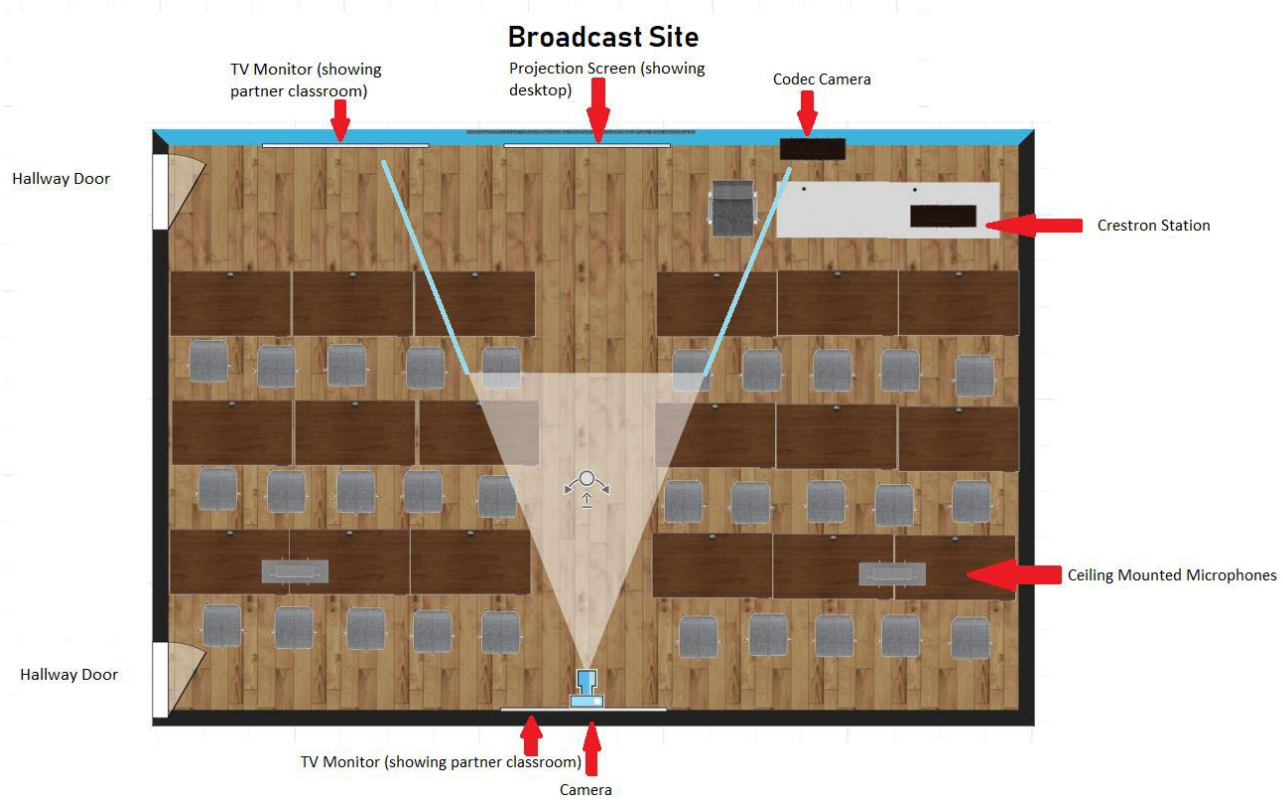


Figure 1:Layout of the broadcaster (local) site

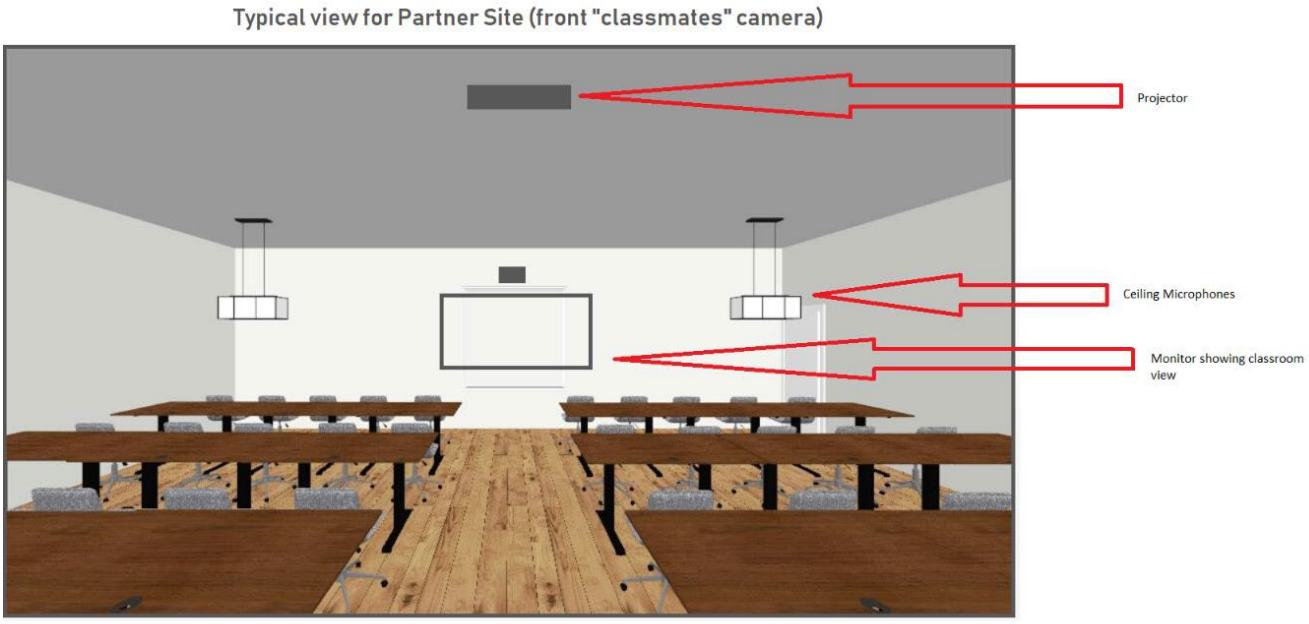


Figure 2: Layout of the partner (remote) site

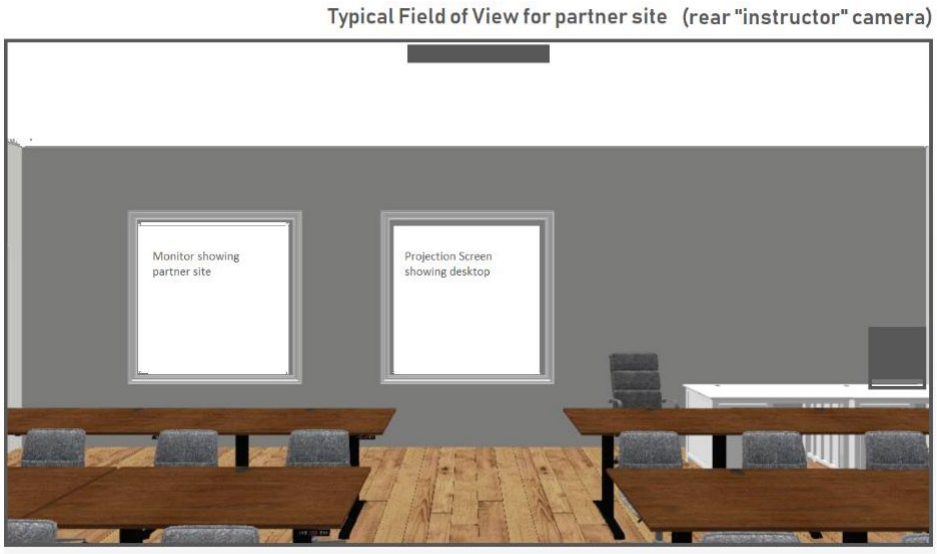


Figure 3: View for the partner site

Teaching pedagogy

Thermodynamics is a 3-credit hour lecture course taken by mechanical engineering students in their sophomore and/or junior years. It is typically taught in a traditional face-to-face format and meets 3 times a week for 50-minute class periods. The course material is extensive with several abstract concepts and complex multi-step problem solving processes. Hence, it is one of the most difficult courses for students. In view of this, all efforts were made to ensure that students would receive the same type of instruction and have access to all resources needed in the site-synchronous format as in a traditional format.

The following addresses the key issues in teaching pedagogy and classroom management:

- The in-class lectures were given using PowerPoint slides that students could see on the projected monitor and/or using the Nearpod app[11] on their personal laptops/tablets/smartphones. All examples/problems were worked on using a paper and pen and projected on the monitor via the document camera. This was done since work on a whiteboard did not project clearly across the sites. Students from both sites were able to interrupt and ask questions at any time during class.
- All course material was made accessible through the university's Learning Management System (LMS) DesiretoLearn (D2L) in advance, prior to beginning the topic in class so students could review, print, download material as needed.
- An online homework tool Connect (available from the textbook publisher McGraw Hill)[12] was used for most of the homework assignments. This was integrated within the LMS and with the textbook used for the course. All homework assignments were due every other week on Sundays at 11:59 pm.
- A graduate assistant (GA) was available on the remote site to handle any technical issues and proctor exams. In-class weekly quizzes and exams were completed on paper, submitted to the GA, scanned and sent to the instructor via email and the same process repeated with the graded work to be returned to the students. Hence, the instructor

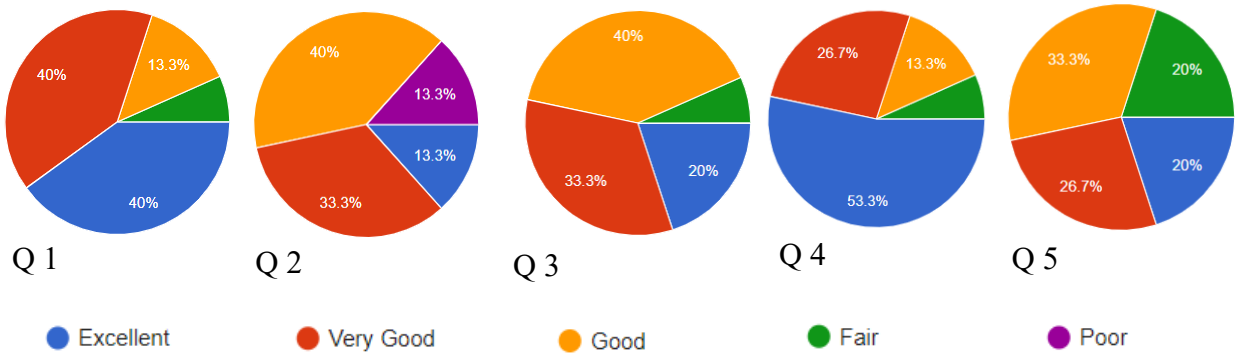
consistently graded all student work which was typically returned within the next class period.
- The instructor was available for office hours via Google Meet, Email, phone, as well as in-person in her office. An email response time of 24 hours was established and mostly met. A document camera and a webcam were used for the Google Meet sessions to share information in real time with the student.
- Peer tutoring provided by undergraduate and graduate students was available for free on both campuses 4 days of the week (Monday-Thursday).
- The instructor was available at the broadcaster site 10-15 minutes prior to class time for any questions.

Apart from replacement of the whiteboard use with the notes projected via the document camera all the above are mirrored from a traditional face-to-face course. Also, as in other delivery methods, a combination of synchronous and asynchronous tools were made available for students. For example, while all lectures/class sessions and virtual office hours via Google Meet were synchronous, online homework assignments and reading assignments were asynchronous for students to complete at their own pace. It has been found that this blended format is preferable for all delivery formats including completely asynchronous courses [13,14,15].

Assessment

To assess the effectiveness of this delivery method, a survey was given to students to complete and return anonymously. The survey was intentionally done mid-semester and after the completion of two exams in order for students to get comfortable with the technology and purely assess the delivery method as compared with most of their other courses which were delivered traditionally. A summary of results of this survey is provided in Tables 1-3. Students were encouraged to not emphasize the instructor's personal teaching techniques in this survey and a separate survey was given to assess the instructor's effectiveness and course content. This survey is currently being completed and hence is not addressed here.

In Fall 2019, the course had 29 students enrolled in the remote site and 2 students enrolled in the local site. As of the mid-semester, 5 of the students from the remote site withdrew from the course for various reasons. The survey was however completed by only 15 students. The survey confirms one major technical issue: 13.3% of the respondents rate the audio from the students to the instructor as poor. Another issue brought forth by the survey is the clarity of the notes via the document camera: 20% rate this as only fair.



Q 1: How clear is the audio from the instructor to the students?
Q 2: How clear is the audio from the students to the instructor (if a student is asking a question or answering one)?
Q 3: How clear is the video (instructor to students)?
Q 4: How clear are the lecture notes (slides) via the projector?
Q 5: How clear are the notes (instructor hand-written during lecture) via the document camera?

Table 1: Summary of results from the survey for Fall 2019 (sample size 15 students).

A few student comments and answers to specific questions are shown in Table 2. While the comments are quite equally divided, it is interesting to note that the number of positive to indifferent comments did increase after about 7 weeks of instruction and 2 exams. Some of the initial reactions may also be attributed to the fact that the decision to offer the course in such a format was made only a few weeks before the beginning of the semester. Hence, all the students had registered for the course assuming it to be in a traditional face-to-face format. The change was only made known to them by the Department Head on the first day of class.

Q. What was your reaction when you realized on the first day of class that your instructor would be on another campus 50+ miles away?
Positive reactions: Figured it would take some getting used to. It was different. No big deal *Not so positive reactions:* Skeptical My hopes dropped as I realized an already difficult course was going to be made more difficult. I can't wait for a power outage or someone to damage the screen. I don't think I'll like this. I was scared and thought it was weird because I thought it was going to be harder to learn when the professor is far away I hope the teacher can speak decent English

I thought it was pretty strange.
I don't like the professor being in a different class room
unsettled
I was in shock on it, and was very anxious about how I would be taking one of the most difficult classes of my major when my teachers being out of the room. I did know that our professor had a good rating and was a well respected teacher of thermodynamics which set me at ease a little bit.

Q. Would you be comfortable taking a similar course (lecture only, no lab) via this technology in the future if needed? 53.3% Yes 46.7% No

Q. Please give us a reason for your answer to the above question.

Positive comments
It seems to work well
Seems to work fine for me so why not do it again.
Because there is no difference. It feels like she is in front of you.
Because it's doable and not too strenuous
I would be comfortable because the method of distance learning is very similar to that of an actual professor. It has its benefits and drawbacks but I think it is pretty straight forward. Its somewhat distracting at times but I think it is a successful method of learning.
I am more interested in this type of class because I feel the material is presented better than in in person classes. I also feel like the professor has to try more to get the student to understand the material which means coming up with new methods of presenting topics and subjects that are found in other classes. The material that I have learned in my current class has stuck with me while in other classes it sometimes will slip my mind after the exam. I feel the reason is because when I don't understand a topic, I watch a YouTube video on the subject.
Grown indifferent to video presentations vs an in person, professor teaching
I would not prefer it but if it meant getting the classes I needed I would take another.
Ultimately, if my only option was to take a course via this format, or drive between campuses, I'd probably pick this format. But I wouldn't prefer it.

Not so positive comments:
It made understanding core material and class engagement very difficult.
It's difficult trying to communicate with the professor who isn't in the same room as you.
Being able to direct someone through a problem on paper in a slower pace enviorent is harder to do as meetings require use of camera that's likely focused on the face of those talking. I will say I only used google meet once and I was stuck on campus that day so I had to use my terrible phone camera alone with trying to find a good place to have the meeting (something I could definitely done a better job of doing) so my thoughts on this could be taken with as a grain of salt.
I don't enjoy the loss of contact and organic discussion that arises from in person communication. Also Im personally enjoy seeing a problem be worked out on a white board. it allows me to process the writte information.
I prefer to have a professor in class, I find it hard to stay focused with the professor on a projector.
I answered no, because I strongly prefer face-to-face interaction with my professors during

classtime. Especially if its a class that focuses heavily on problem solving. Its just so much easier to point to something on the board, or to get clarification on a concept, when the professor is right there with you. If, on the other hand, it was a strictly lecture course, like a history or English course, I'd have no problem with this method at all. I'd prefer to be able to ask the professor questions easier. I feel a large disconnect between the professor and students while leads to me having to teach alot to myself

Table 2: Summary of comments from students in Fall 2019 (sample size 15 students).

Three of the comments in Table 2 have been highlighted to show that the current generation of students does have a significantly different learning style from a student body of the previous generation/decade. If instructors can embrace it and use similar technology in traditional courses as well, it would benefit the overall student's learning experience.

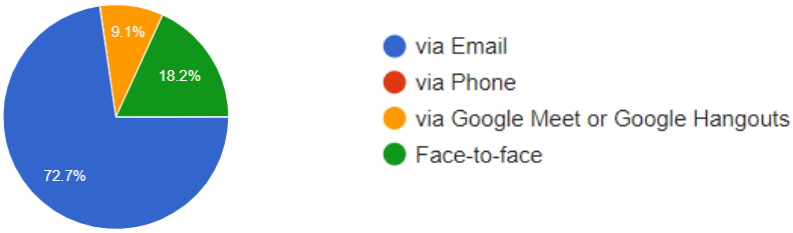
Which mode did you use to contact the instructor during her office hours?	

Table 3: Mode of contact during office hours (73.3% of the respondents made an attempt to contact instructor outside of class time).

Table 3 shows that majority (72.7%) of the students contacted the instructor via email and only 9.1% utilized Google Meet. This distribution is very similar to that in a traditional face-to-face course as well. Students in the current generation prefer to use email as a communication tool with instructors.

Faculty's Perspective

The author agrees with most of the student survey results. However, the students' comments are certainly not unbiased between the delivery method vs. course content. From the perspective of a faculty member teaching in this format for the first time, there was considerable preparation work as well as a steep learning curve in the use of the technology. For example, lecture notes had to be completed well in advance of the class period so that they could be published on the university's LMS as well as on Nearpod for students to access during class. Similarly, quizzes and exams had to prepared in advance in order to give the graduate assistant ample time (24 hrs minimum) to print out and make appropriate number of copies for the class. The instructor had to make a conscious effort to not pace in the classroom so as not to trigger the tracking system of the camera and to use the document camera in lieu of the whiteboard. Many students did not bring a personal laptop/tablet to class, so they were able to only view either the lecture notes (via the projector) or the instructor notes (via the document camera) at any single moment. In order to accommodate this, the instructor had to go at a slower pace, re-draw many of the schematics during problem solving sessions and learn to quickly toggle between the two screens at any time.

Overall, the instructor feels that while the teaching method and content were certainly not compromised, the instructor-student relationship that is normally developed over a semester was certainly missing. Hence, while cognitive learning in a site-synchronous format is comparable to that of a traditional format, the absence of the social element needs to be addressed to make the overall learning experience more beneficial and enjoyable for all [8].

Concluding Remarks and Future Plans

In this paper, the author presents the implementation of a lecture-based course, Thermodynamics via a site-synchronous technology. Preliminary assessment results and student comments show that students struggled with this delivery method. However, the overall student performance (grade distribution) in the course was like that in a traditional face-to-face format. The course was offered in this format for the first time and as a pilot study in Fall 2019 and the current plan is to offer this and several other courses in this format in subsequent semesters.

Future assessments including student surveys and relative student performance will be used to evaluate and assess this mode of delivery for this and other courses. Efforts will be made to implement tools and strategies to enhance the student's learning experience such as:

- In-class problem solving sessions proctored by the GA at the remote site (with majority of the students) and guided by the instructor remotely from the local site.
- Instructor-initiated and monitored discussion boards on the University's LMS.
- Office hours offered locally by faculty teaching different sections of the same course.

Once deemed successful, this method of delivery can address the needs of a larger student body across multiple campuses.

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Priya T. Goeser

Priya T. Goeser is a Professor in the Department of Mechanical Engineering, Georgia Southern University – Armstrong Campus, Savannah GA. She received her Ph.D. in Mechanical Engineering from the University of Delaware and her B. Tech in Mechanical Engineering from the Indian Institute of Technology, Chennai, India. Her current research interests are structural health monitoring, functionally graded materials and innovative teaching methods in engineering education. She is the primary instructor for Thermodynamics on the Armstrong Campus. She has also been trained in the use of the Site-Synchronous Technology and was the first instructor to teach engineering courses using the technology at Georgia Southern University.