Using HyFlex in Statistics for Engineers and (Data) Scientists

University of Michigan

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Note to our readers: This chapter is the work of both authors but is presented as a first-person narrative. Jack has been using the HyFlex model since 2011 and tells the story from their perspective. Melinda has been contributing to and consulting on Jack's work since it was introduced at Michigan in 2014. Since Jack is the "user" of the model, we decided to present this chapter from Jack's point of view.

HyFlex at the University of Michigan (UM) actually began at The Ohio State University (OSU), as I was formerly an instructor at OSU before joining the instructional team at UM. Both OSU and UM are large, public land-grant universities in the Midwest, and they are quite comparable in many aspects, including the growing popularity of various online/hybrid modalities and the increasing need for flexible options to meet the requirements of students trying to graduate in impacted majors that may have more students who need to take a course than there are seats available. As a discipline that serves many client departments, statistics departments need to address the needs of a diverse student body, and create more individualized options for students for whom statistics is not their primary focus. HyFlex allows students to complete their statistics course their way, using the method that works best for them on a day-to-day basis. Moreover, in addition to the universities themselves being similar, the

implementation of HyFlex at OSU and UM has been similar in that, at both universities, HyFlex was first used in a large introductory statistics course (with 200-400 students per lecture and 25-30 students per recitation/lab section) and then migrated to a large upper-level probability and statistics course (with 100-200 students per lecture and no lab sections). This chapter will focus primarily on the implementation of HyFlex in Stats 412, an upper-level probability and statistics course at UM. (See Miller, Risser, & Griffiths (2013) for information about the implementation of HyFlex in introductory statistics at OSU and Miller (2016) for a discussion of HyFlex in Intro Stats at UM.)

In terms of the overall structure of the learning environment, Stats 412 is a one semester, 3-credit hour lecture course with no lab or recitation section and meets for 3 hours/week for 14 weeks. The course has a Calculus 3 pre-/co-requisite. Students in Stats 412 come from both the College of Engineering (CoE) and the College of Literature, Science, and the Arts (LSA). The vast majority of the students are undergraduates, mainly upper division, with the minority (about 10-15%) coming from various graduate programs. Of the undergraduates, about 85% are from CoE, with students from aerospace to mechanical engineering. Computer Science and Data Science majors are prevalent from both colleges. The Data Science major is relatively new at UM and expects to continue increasing in enrollment. Stats 412 is a required course for the Data Science majors, one of two options to meet the statistics course requirement for the Computer Science majors, and is an upper-level technical elective for students majoring in engineering. One interesting aspect to having so many upper division CoE students is that many of them are completing capstone and other significant projects and looking for internships or permanent jobs during the term, which places an unusual demand on their time constraints. Additionally, interest (and enrollment) in Stats 412 among engineering majors has increased significantly in the past five years whereas department resources have remained steady—thus Stats 412 was an ideal course in which to

consider adding HyFlex in order to increase enrollment capacity with the same faculty resources.

How HyFlex Appeared on My Radar

My journey with HyFlex began when OSU was planning to make its transition from quarters to semesters (semesters began with Autumn 2012). In preparation for that transition, I proposed "Semester Conversion: Too Many Students, Too Little Time" for a $10,000 Departmental Impact Grant from the OSU Office of Instructional Technology (OIT). "Too Many Students" described a potential increase from 350 students per quarter to over 500 students per semester. Finding large lecture halls on campus at times when students want (and are able) to attend class would be increasingly difficult. The proposed solution was to give students choices—students could choose between face-to-face and synchronous, live stream lecture. "Too Little Time" referred to a 20% decrease in contact time spent in small-group discussions (recitations) with graduate teaching assistants (GTAs). This cut in small-group time necessitated finding a way to make students more responsible for the material they learned in lecture. The proposed solution was to have an on-line lecture review and assessment due after every lecture and before recitation. We also recorded and published all the streamed lectures allowing all students to review the lectures, at any time and in any place.

With a limited number of large lecture halls and impending increased enrollment per lecture section, already scarce resources were going to be at even more of a premium. My thought was that allowing students to attend synchronously in person or via remote stream or asynchronously watch lecture recordings would enable more students to enroll in a course while not increasing the actual number of physical seats needed in the classroom, thus not necessitating another precious time slot to be taken from the scarce large lecture halls. I successfully used the HyFlex model at OSU for the academic years

2011-2013, ending only because of my transfer to teach at UM. Although I was not able to overenroll my lecture sections at OSU and teach more students in the same number of physical classroom seats, our research (Miller, Risser, and Griffiths 2013) indicated that we would be able to move in that direction. Unfortunately, OSU Statistics stopped using HyFlex when I left; other disciplines, including Animal Science, Mathematics, and Economics, have used and expanded on HyFlex principles after I introduced the technique to OSU during the 2011-2012 academic year.

The HyFlex Model Comes to Michigan

Although space needs are universal, the demands on space that came with a change from quarters to semesters were not present at UM. Still, after experiencing the success of HyFlex in introductory statistics at OSU, I was eager to bring the technique to UM. As such, I first introduced HyFlex in a very large (1500-1800 students per semester) introductory statistics course at UM, but found that the various HyFlex options were underutilized by students in that course. Upon further reflection, I realized that students already had a number of different attendance options in that course, and thus HyFlex was not really needed by those students. I knew the HyFlex model could be a successful model if the students have a need for it (as Brian Beatty says, "If there is no need, don't do it!"), thus I decided to introduce the model to students in Stats 412, where, to my delight, the HyFlex model has proved much more beneficial to students (Miller and Baham, 2018a, 2018b, 2018c).

As mentioned previously in this chapter, Stats 412 is taken by students primarily enrolled in both the College of Engineering (CoE) and the College of Literature, Science, and the Arts (LSA) at UM. CoE is housed on UM's North Campus, and LSA is housed on UM's Central Campus. Because Stats 412 is taught out of an LSA department, all Stats 412 sections are taught on Central Campus. The distance

between the two campuses is not inconsequential—it is at least a 30-minute walk between classes if a student needs to get between North and Central campuses, but classes only have a 10-minute break between them. Remote attendance allows students on North Campus (or elsewhere) to attend a class on Central Campus without having to worry about being late to any classes. Thus, streaming synchronously and remotely allows students to attend all their classes without missing vital information and without sacrificing the student classroom experience (e.g., access to instructor in real time, etc.).

Surprisingly, my model for HyFlex somewhat mirrors the models of others even though it developed independently. When preparing to submit the OSU grant proposal, one instructional technologist asked why I didn't just pre-record my lectures in my office. The best way to explain it is that I need at least some students to be with me in person so that I can teach—I rely on the students' questions and facial expressions to drive the pace of a class meeting and did not feel it was possible to do this while pre-recording lecture material. HyFlex was borne of my desire to offer the chance to take a statistics course without worrying about how many students could fit into a room—I wanted students to be able to attend remotely if they chose.

In Stats 412, HyFlex means that students can attend class in person or remotely while class meetings are happening. It is important that students have equivalent learning opportunities regardless of how they attend lecture. The experience of attending class in person or remotely should also be fairly seamless for students—they should be able to make their choice about attendance mode based on what is best for them on each day. Students should not have to decide when they register for class that they want to attend solely in person or solely remotely for the entire term. The flexibility of daily choice allows students to change how they attend throughout the term, whether predominantly in one mode or alternating between attendance modes.

Regardless of how many students choose each attendance modality, the in-person lecture (slides and instructor audio) is live streamed and can be accessed with reduced or standard latency via URLs provided to the students in Canvas (our LMS), depending on the technology available to the student (i.e., bandwidth) on a particular day. A backchannel is used to provide equivalent learning opportunities to students attending remotely—the backchannel lets students ask questions of the instructor and have them answered in real time even though they are not in the same physical space.

Because Stats 412 is not listed as "HyFlex" in the UM course catalog, students who may be unaware of the HyFlex design of the course learn about it during the initial class meeting and have the following information in the syllabus:

Ways to Attend Class: Stats 412 is taught using a HyFlex (hybrid-flexible) model. This means that you can choose the way you attend class to best meet your needs. You may choose how you attend on a daily basis and may attend in person or via streaming technology. Details about this HyFlex course can be found [later in the] syllabus.

The details given to the students for the Winter (known elsewhere as Spring) 2019 semester are included at the end of this chapter.

Implementation of HyFlex at Michigan

Implementation of HyFlex at UM would not be possible without the efforts of folks from the UM LSA Instructional Support Services (LSA-ISS) office. The LSA-ISS team members consistently work with me to find the best solutions for streaming lecture and for the backchannel. They also make a lecture capture (recording) of the in-person lecture just in case technology lets us down on any particular day.

Live Streaming

Since introducing HyFlex at UM, we have used several methods for live streaming lecture, beginning (2014-2015) with Adobe Acrobat (which I had used at OSU). After Adobe Acrobat, we streamed with the "active learning platform" (2015-2016) that had been developed by a colleague at UM and is now part of Echo360. For the past few years (beginning Fall 2016) we have used an Epiphan Pearl live streaming box. So far this has worked well, so we continue to use it. During the 2018-2019 academic year, students were offered two options for streaming—one at standard latency and the other at reduced latency. There is a 30-60 second lag between real time and the stream with standard latency that is cut to 10-15 seconds with reduced latency. While it would be ideal to have no lag between real time and the stream, that is not currently possible with our technology. Students tend to use the reduced latency stream unless they are somewhere with less broadband and thus need to use the standard latency stream.

Backchannel

The backchannel allows students attending remotely to ask me questions during lecture; all backchannel technology used so far has been free of charge to students. One particular advantage of the backchannel is that, because it is available to all students, even those who are physically in the classroom can utilize it to ask questions (which may otherwise be daunting in a large lecture class). With the exception of the single year we used the active learning platform, our backchannel was run through an instructor subscription to Poll Everywhere. Poll Everywhere worked well for the most part—students could ask questions via Poll Everywhere, and I repeated them aloud and answer them during lecture (so all students hear the question and the answer).

The one element of the backchannel I felt was missing while using Poll

Everywhere in the past few years was the students' ability to see and answer each other's questions. When I started using the HyFlex model at OSU, there was a static URL that I could give students so they could see the backchannel and comment amongst themselves, but that static URL unfortunately is no longer be available with Poll Everywhere. When it was available, students were great at answering each other's questions. The backchannel chat allowed by such a static URL was terrific for quick little things that did not need to be broadcast to the entire lecture. Without the ability for all students to access what has been previously asked on the backchannel, some questions may be asked multiple times or interrupt lecture material. Beginning Fall 2019, I tried a platform called YellowDig, but it does not update in real time, so, while the platform seemed promising, it did not fit the purpose. LSA-ISS staff members and I are looking into alternatives, but for now I am sticking with Poll Everywhere.

Set Clear Expectations

In addition to the stream and the backchannel, it is important that students understand what is expected of them in terms of HyFlex and with technology in general. All details are provided in the course syllabus—the HyFlex section of the syllabus explains how students access the live stream and the backchannel and gives students an overview of my expectations for them with respect to the technology used for HyFlex. .

With Technology Come Challenges

Anyone who uses technology knows that they should always have a "Plan B." When we rely on technology to stream to the majority of our students, it is difficult—if not impossible—to communicate with the remote students if there are technology issues (e.g., streaming box needs to be reset, there was a power outage in one part of campus, etc.). In my eight years using the HyFlex model, there have been only

two days when everything went awry with technology and there was no way to stream class (Plan B was to record the in-person lecture and post it). When minor issues have arisen, the audio-visual technician in the lecture room has been able to troubleshoot almost anything. I have learned to be patient and calm when it comes to technology. Students have been very understanding on the rare occasion when something goes wrong.

Recording Availability Debate

One of the biggest challenges of the HyFlex model has nothing to do with HyFlex itself or the technology involved. Rather, it is with the availability of lecture recordings and the evolution of my pedagogical practices regarding recording availability. The first five years I used HyFlex at Michigan, I posted lecture recordings on the learning management system for the duration of the term. This practice ended after the Fall 2017 term when student synchronous (in-person or live streaming) attendance was dismal and, for the first time since I started using HyFlex in 2011, poor student performance on homework and exams indicated that students were not watching the lecture recordings. HyFlex is intended to help students and to offer them flexibility, not to "design a feature that inadvertently facilitates poor student behavior" (Brian Beatty, personal communication, 2019). Even so, data collected from Fall 2017 students indicated that, with the recordings available, students meant well and planned to watch the videos, but only about 25-30% of students attended class (includes all methods: in person or remotely) and only a minority of the students who did not attend watched the recordings. There are ways to add credit or gamification to increase the likelihood that students will watch videos in a timely manner, but this would contribute to "workload creep" (addressed below). So, while I want the students to have flexibility and choice, it seems that I need to make the choice about recordings for them as a group, not taking individual choice or learning styles into account. This poor attendance and poor command of the material as evidenced by homework and exams resulted in a

policy change—recordings were not made available to students during the Winter 2018 term. During that term about 60% of students attended class regularly, with about 16% attending in person and about 44% attending remotely. Although not causal, this demonstrates an association between lecture recording availability and class attendance. Furthermore, students during the Winter 2018 term had far better attendance and performance on homework and exams than students in Fall 2017, so I continued the new policy of not making lecture recordings available.

Unfortunately, in the following year extreme weather and class cancellations during the second week of the Winter 2019 term required me to post a recording from a previous term so that we did not get too behind in the material. After watching the recording, one student inquired about having recordings available for all lectures, and I ultimately opted to make recordings available for 24-48 hours after class meetings for the remainder of the Winter 2019 term, dependent upon student performance. Student performance on Exam 1 seemed to indicate that they were likely watching the recordings, so I continued to post them during the term, even though performance on Exam 2 dropped. Fortunately, student performance on the final exam suggested that students were once again actually watching the recordings, so I felt better about having the recordings posted. As mentioned above, I do not have any lecture-based quizzes during the short period recordings are available, so there is no "guarantee" that students will watch the videos during the short time they are available.

As for the future, admittedly, I am conflicted about lecture recordings—on principle, I want the recordings to be available for students for many reasons, including for material review and unavoidable student absences (athletes, interviews, etc.). In practice, I question how often students who do not attend synchronously really watch the recordings. My (anecdotal) findings are consistent with those documented in Beatty, Merchant, and Albert (2019).

Additionally, when recordings are available, synchronous (in person or remote) attendance tends to be lower and there are fewer questions on the backchannel (less student involvement) than occurred when no recordings were posted. Weighing the pros and cons, at the moment I continue to allow recordings for 24-48 hours after a class meeting during the Fall 2019 term. I might consider making the videos available again for exam preparation, but am afraid that students will wait to binge watch as many recordings as they can prior to taking their exams. Publishing and unpublishing the videos during the term must be done manually and contributes to workload creep. Allowing the recordings for a short period of time ideally encourages students to stay on top of the material, but at a time cost that is non-trivial.

Workload Creep

One of the original reasons that I started using the HyFlex model was so that I could teach more students without taking up more physical classroom space. Historically, I have allowed more and more students to take my classes as wait lists far exceeded available spots, and my enrollments at OSU increased from 50 to 200 students per lecture section, with similar increases at UM. The toll this takes on instructors and graders is not minimal. More students enrolled means more homework assignments and more exams to grade—I have graders for the homework, but I choose to grade the exams myself. However, more than the extra grading, it's the barrage of email messages, alternate accommodations, special office hour demands, etc.—in essence, the increased psychological and cognitive load—that come from the increased number of students that has led me to cap my enrollment at UM. Unlike with our large introductory statistics course, there is no administrative help for Stats 412, so all emails are handled by me as the instructor. And, in this digital age, it appears that students are more likely to send a quick email to ask a question than they are to look up the information in the syllabus (e.g., "when is the exam?" or "can I turn this homework assignment in late?"). This non-trivial increase in administrative duties led me to have my

department chair cap the course at 100 students per section beginning Fall 2018. Limiting the number of seats in the course goes against my desire to teach as many students as want to sign up for the class. However, I recognized that my students were not getting my best when I was overwhelmed, so I had to scale back. Although HyFlex allows us a way to teach 2-3 times the number of students in the same amount of physical space, it does not compensate for the administrative (and cognitive) load that comes with the increased number of students, and thus must be applied carefully and wisely so the increase in students does not detrimentally decrease the learning experience.

Students Like HyFlex but Adoption Is Slow

By far the most important student outcome of the use of HyFlex at UM has been affective in nature. This is consistent with findings from Miller, Risser, and Griffiths (2013) about HyFlex at OSU. Students like having a choice about how they attend lecture. They also like being able to ask questions through the backchannel. Primarily, though, the opportunity to attend class remotely has been well received by students. Whether a student is in ROTC and has training until 0800 on North Campus but has time to pop home and shower before attending an 8:30am class remotely or whether a student has a difficult time concentrating in a large classroom and appreciates being able to stream lecture in a quieter environment, students like the HyFlex model for Stats 412. Many student evaluations have mentioned that they wish more classes used the HyFlex model, and student focus groups have indicated similar affective responses.

Additionally, for students who mostly attend in person, HyFlex has allowed students to attend lecture on days when they have been unable to be physically present on campus. Remote attendance has allowed students to come to class while attending out-of-town professional conferences, and student athletes have attended

remotely when out of town for games. One student even attended class via car while traveling to a friend's wedding 1000+ miles away (the student was a passenger in a car with WiFi connection)! No face-to-face only class can offer these opportunities to students.

Since students really like the HyFlex opportunities they have at UM, certainly it has taken off as an instructional model, right? Unfortunately, that hasn't been the case. As far as I know, HyFlex has not caught on at UM in the same way it did at OSU. The large introductory course at UM that I initially introduced HyFlex in does use HyFlex for exam reviews, but no other statistics courses use the model. It is quite possible that some other instructors in other departments are live streaming their lectures in the lecture halls that have the streaming technology and that I am unaware of it.

Try HyFlex!

Utilizing the HyFlex model in my statistics courses, both at OSU and at UM, has been extremely rewarding. By engaging in HyFlex techniques, I am able to provide my students with continuous choice of class attendance and help to encourage them to take ownership of their own learning. As a faculty member and educational instructor, my ultimate goal is, of course, for students to learn the material and be able to apply it in their other courses and work. If students aren't able to attend class or ask questions, they may quickly fall behind and have difficulty catching up. Even the best students may have this happen. Especially as students advance in their educational careers, the demands on their time can become overwhelming, and non-major courses, although vital, take a back seat to job interviews and capstone projects. A rigid course structure would pit these various elements at odds with one another and would force such students to choose between which lecture(s) they would attend that week. I believe we should be supporting our students in their aspirations, not limiting them. By providing flexible lecture attendance options, I feel

that I am contributing to positive educational experiences and that I am engaging in pedagogical techniques that exemplify my personal teaching philosophy.

In addition to my personal affective gains, students at UM have continually responded positively to having HyFlex available for Stats 412. The flexibility has helped students in a variety of situations, and students continue to report appreciating the choice that HyFlex provides for them. As such, I will continue to work with my IT staff to improve both the stream, perhaps by reducing lag and automatically removing recordings, and the backchannel, hopefully by adding student-to-student interactions so students can learn by teaching others. All indications from students are that they are very pleased with my HyFlex offering, so I will continue to use it in all large courses that I teach.

If you read this chapter, you are at least interested in the HyFlex model—that's great! I think HyFlex is an excellent way to offer our students choice and flexibility in their learning. I encourage you to talk to your instructional technology (IT) support staff about what HyFlex would look like for you. There are many options for streaming and for the backchannel, some of which might already be available at your school. Additionally, you may be able to find ways to incorporate aspects of HyFlex in your teaching even if your school does not already have certain technologies available. HyFlex can be implemented in a variety of ways at any course level for just about all course subjects, so I encourage you to get creative and try it out!

In sum, I look forward to us working together to form a community of educators who offer the HyFlex model, and to ways in which together we can develop technology that meets our needs to expand the model beyond its current reach, in order to provide the best opportunities for our students.

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Appendix A. Using Technology for Stats 412 ([download PDF file here](#))
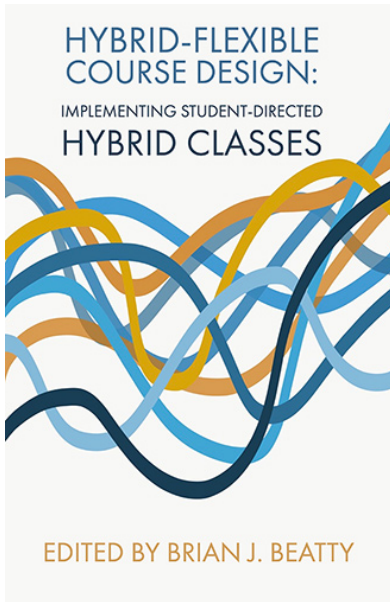
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