

COMPARING THE HYFLEX (HYBRID-FLEXIBLE) MODEL OF COURSE DELIVERY IN AN INTRODUCTORY STATISTICS COURSE AND A PROBABILITY AND STATISTICS COURSE FOR ENGINEERS AND SCIENTISTS

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The HyFlex (hybrid-flexible) model lets students choose how they attend lecture (in person or remotely) each day based on personal decisions and experiences. Prior research at The Ohio State University (OSU) found important student gains in affective ways. Research on the HyFlex model for Stats 250 at University of Michigan (UM) showed similar results, although the remote option was not used as much as it was at OSU. HyFlex moved to UM's Stats 412, a calculus-based probability and statistics course, in Fall 2017 and was adapted for Winter 2018. Experiences in adoption of HyFlex in the two different types of courses will be compared. Tips and suggestions for adopting HyFlex will be discussed, as will student outcomes, which were mostly affective in nature.

INTRODUCTION

As new technologies have emerged and improved drastically over the last quarter-century, instructors and academics have increasingly sought ways of incorporating such technologies into their classrooms to aid in student learning and understanding (e.g., Miller, Risser, and Griffiths, 2013; Drouin, 2014; Beatty, 2006, 2010). New technology has allowed for distance courses to be taught fully online as well as in hybrid formats, and a variety of study tools and course aids have been developed by researchers, academics, instructional faculty, and textbook publishers alike. In addition to online and hybrid formats, another instructional format was created that took advantage of new technologies, called the Hybrid-Flexible (HyFlex) model for teaching. The HyFlex model was originally designed for graduate courses to allow better access to the courses for students who might be commuting up to 60 miles for class (Beatty, 2006). The HyFlex model gives students the choice to attend class in person or via synchronous remote stream and to make that choice on a daily basis. In other words, unlike online and hybrid models which typically have a fixed course structure for the entire semester, the HyFlex model does not require students to make a choice at the beginning of term and then stick with it whether their choice works for them or not; rather students are able to make different choices each day depending on what works best for them on that day (hence the format is “flexible”). A key component of the HyFlex model is that students attending remotely have equivalent opportunities to engage with students attending class in person and with the faculty member in synchronous time (Beatty, 2010; Miller, Risser, & Griffiths, 2013), which is an important and sometimes overlooked aspect of online course delivery.

The first author initially began research on the HyFlex model in an introductory statistics course at The Ohio State University (OSU) in Fall 2011 in an effort to ease space issues and time constraints that came with OSU switching from quarters to semesters (Miller, Risser, and Griffiths, 2013). The HyFlex model was implemented at the University of Michigan when the first author accepted a teaching position there. Implementation began in Fall 2014 in Stats 250 (Introduction to Statistics and Data Analysis) and expanded to Stats 412 (Introduction to Probability and Statistics) beginning Fall 2017.

This paper discusses the technology needs of implementing HyFlex and compares the implementation and success of the HyFlex model for teaching in algebra-based introductory statistics courses to its use in a calculus-based probability and statistics course. Course structure and the availability of recordings and other resources will be addressed in terms of perceived success of the HyFlex model.

TECHNOLOGY NECESSARY FOR IMPLEMENTING HYFLEX

To implement HyFlex appropriately (i.e., the way it has been done by researchers), one needs a classroom that has the capability to synchronously stream the lecture and to allow for a “backchannel” to provide equivalency of communication for students attending in person or remotely (e.g., Miller, Risser, and Griffiths, 2013; Beatty, 2006, 2010).

In general, a backchannel is a virtual space (similar to a chat room or a group text) available to audience members to communicate with others both inside and outside of the physical presentation space, and this may or may not be with the presenter's knowledge/monitoring (Atkinson, 2009). In a HyFlex classroom, ideally students would be able to ask and answer questions of the lecturer and each other, but current technology does not offer an ideal way for the students to see the backchannel and thus questions can only be addressed to the lecturer. With the current setup, Miller has their tablet computer for lecture and notes and has another computer open to the backchannel so that they can see the questions as they come in. When questions come in, whether via the backchannel or in person, Miller repeats the question for all students to hear and then answers the question. The current backchannel platform being used is Poll Everywhere, however past technologies included Top Hat and Echo 360's Active Learning Platform.

A reliable stream out from the classroom is imperative. Currently the technology being used is an Epiphan Pearl streaming box that Michigan's instructional technologists have set up in all rooms that stream lectures. Previous streaming technology included Adobe Connect and Echo 360's Active Learning Platform (Miller, Risser, & Griffiths, 2013; Beatty et al., 2016). All of these platforms allowed for synchronous remote viewing, and most recorded lectures recorded as well.

INITIAL IMPLEMENTATION OF HYFLEX AT OHIO STATE

Miller's involvement in HyFlex began in 2011 with a Departmental Impact Grant at OSU that endeavored to help deal with OSU's switch from quarters to semesters, a change that brought both the demand to teach 50% more students per term and a 20% decrease in the amount of contact hours for the recitation (lab) portion of the course. The course Miller adopted HyFlex in was "Introduction to the Practice of Statistics" (Stat 145 on quarters, Stat 1450 on semesters), which was one of four different introductory statistics courses offered by OSU's statistics department, required college algebra, and was geared towards students on the social science and science side of the College of Arts and Sciences. Stat 145 served approximately 1000 students per academic year and was a lecture-lab (recitation) setup in which students were registered for a particular lecture section, and that lecture section was broken up into several recitation (lab) sections. Students in a particular recitation were all enrolled in the same lecture section.

Research into the impact of HyFlex in Stat 145 found no significant differences in course performance between those who attended in person and those who attended remotely (Miller, Risser, and Griffiths, 2013). The main findings of the research were affective in nature, primarily with regard to flexibility of lecture attendance and participation levels. Student motivation for their primary mode of attendance indicated that "most students chose their daily attendance based on whatever worked with their schedule on that particular day" (p. 18), and various factors such as "weather conditions, other class responsibilities, extracurricular commitments, and the need for extra sleep motivated [remote streaming] attendance" (p. 18). Students also felt increased participation in class tied to the in-class polls which were described as "helpful, engaging, and a fun way to check comprehension without the pressure of getting an answer wrong" (p. 19), and even induced "the feeling of being in a small class" (p. 19).

HyFlex continued to be used in Stat 145/1450 while Miller was at Ohio State and was later adopted by courses in Animal Science, Mathematics, and Economics. The success and promise of HyFlex prompted Miller to remain committed to the model when moving to Michigan.

INITIAL IMPLEMENTATION OF HYFLEX AT MICHIGAN

Miller moved to the University of Michigan in Fall 2013 and introduced the HyFlex model to Stats 250 (Introduction to Statistics and Data Analysis) in Fall 2014. Stats 250 has a very different structure than did Stat 145/1450—Stats 250 is the only introductory statistics course at Michigan, serves students in most majors (except those who take a statistical literacy class and those who take a calculus-based probability and statistics course), and has no mathematics prerequisite. Stats 250 is the largest course offered in the College of Literature, Science, and the Arts (LSA) at Michigan. The course serves approximately 4000 students per academic year, broken into six lecture sections and between 60 and 70 weekly labs each semester. Unlike at OSU, labs are not associated with specific lectures, so labs consist of students who may be in any one of the six lectures and have any one of the several lecturers teaching that term. In addition, students can

choose which lecture to attend (i.e., they do not need to attend the lecture they register for) and lecture recordings are made available to the students. Until Winter 2017, filled-in notes were posted on the course management system. Thus, students in Stats 250 can get course information by attending any lecture they wanted, listening to the recordings, or looking at the filled-in notes online.

As mentioned, the first offering of a HyFlex lecture was offered in Fall 2014. Miller's lecture was the only lecture section offered in this mode. In conjunction with instructional technology experts, they began with the setup that had worked at OSU (Adobe Connect for streaming with Top Hat serving for the backchannel). Beginning in Fall 2015, we switched to the Active Learning Platform (ALP) of Echo360, which served for both the stream and the backchannel. Fall 2016 brought another change in technology to using an Epiphan Pearl streaming box and Poll Everywhere for the backchannel. Technology switches primarily occurred as we tried to find the best platform for allowing synchronous streaming and a backchannel. We recognize that the frequent change in technology might impact our results, however each time new technology was introduced students were fully apprised how to use the technology.

During Winter 2016, 299 students were registered for Miller's lecture section of Stats 250, and the total number of students in Stats 250 was 2181. Because students were allowed to attend any lecture section they wanted, students from all lecture sections were invited to use the HyFlex options. Using system software that followed students' streaming usage, the following summary gives a sense of participation rates:

Synchronous remote attendance of lecture (34 possible lectures) for the entire term:

- 206 unique students took advantage of the remote stream
- Of the 206 unique students, 108 (52.4%) have attended once or twice; 70 (34.0%) have attended 3-10 times; 20 (9.7%) have attended 11-20 times; 8 (3.9%) have attended 21 or more times (most is 29 times)

Video views of recorded lectures for the entire term:

- 151 unique students watched video recordings
- Of the 151 unique students who watched video recordings, 46 (30.5%) have watched once or twice; 47 (31.1%) have watched 3-10 times; 40 (26.5%) have watched 11-20 times; 18 (11.9%) have watched 21 or more times (most is 29 times)

Many students would check out the remote stream during the first week of class (some while attending lecture in person), so if we ignore the students who attended remotely only once or twice, 34.0% of users (70 of 206; 3.2% of the entire course enrollment) utilized the synchronous remote option sparingly and only 13.6% of users (28 of 206; 1.3% of the entire course enrollment) used the synchronous remote option on a regular basis. The percentage of students who attended lecture in person was not counted, but it was very low, particularly beginning after the first exam in the course.

While not many students took advantage of the synchronous remote option, research did show student gains in the affective domain, paralleling the research from OSU. Students who took advantage of the HyFlex option had many reasons for their choices. For example:

- One student commuted to campus and would attend lecture in person on days she had lab, but would attend remotely on other days.
- The same student also attended via car while riding with friends to a wedding in Florida
- One student-athlete attended remotely when she needed to be away for softball games.
- One student who always attended face-to-face attended remotely the only day he had to miss class in person due to a conference.

Overall, students appreciated and used the different lecture attendance options. Students' primary mode of attendance seemed to be based on their preferred learning method, but scheduling came into play at times. Most importantly to the researchers, according to focus groups, students who attended via remote stream felt like part of the classroom community because of their ability to communicate with the instructor in real time via the backchannel.

HYFLEX IN A CALCULUS-BASED PROBABILITY AND STATISTICS COURSE

HyFlex at Michigan moved from Stats 250 to Stats 412 (Introduction to Probability and Statistics) beginning Fall 2017. Stats 412 is a one-semester calculus-based probability and statistics

course designed to serve students majoring in most engineering disciplines, computer science, other sciences. In addition, some graduate students take Stats 412 to fulfill a statistics requirement or to get a sense for statistics as part of their program.

While Miller originally thought that HyFlex would not be successful for Stats 412, that perhaps the model was not transferable to Michigan (based on its limited use by students in Stats 250), Baham urged them to reconsider. Through that discussion, both researchers realized that Stats 412 was an ideal sandbox in which to implement HyFlex. The vast majority of students taking Stats 412 are based on the University of Michigan's North Campus, which is approximately a 20-30-minute trip away from Central Campus, where Stats 412 is taught. With 10-minute breaks between classes, it is virtually impossible for these students to attend a course on North Campus and then Stats 412 on Central Campus (or vice versa) without leaving one class early and/or arriving late to the next. The ability to synchronously and remotely stream Stats 412 allows these students to attend back-to-back classes without missing any of either class.

During Fall 2017, Miller taught two sections of Stats 412, one at 8:30AM and one at 2:30pm. The daily attendance choice for students included attending in person, attending remotely, or listening to recordings of the lecture. Miller was disheartened by attendance, both in person and remote, during 2017. In the 8:30AM section, an average of 21.9 students (15.1%) attended in person and an average of 20.2 students (14.0%) attended remotely, with both sets of numbers plummeting toward the end of the term. In the 2:30PM section, an average of 21.7 students (15.3%) attended in person and an average of 11.1 students (7.8%) attended remotely, again with both sets of numbers dropping significantly as the end of the term neared. Many students (a little over 40% in each section) reported that they planned to watch the recordings, but their class performance did not indicate familiarity with material only discussed in lecture that would confirm they watched the recordings. Because of the low in-person and remote streaming attendance rates in Fall 2017, and prior research that suggested student attendance may drop if lecture recordings were made available (e.g., Drouin, 2014), Miller and Baham decided to not offer recordings during the Winter 2018 term.

A brief survey was recently administered to students currently enrolled in Stats 412 during Winter 2018 (which is still in progress at the time of the writing of this paper). The survey was taken a little over halfway through the Winter 2018 semester, between Exam 1 and Exam 2. Of the 191 students enrolled in Stats 412, 165 (86.4%) replied to the survey.

When asked in what way(s) they have attended lecture, 72.7% of respondents reported having attended in person and 89.1% have attended via the remote stream (16.4% of students reported not attending lecture). Because HyFlex allows students to choose on a daily basis how they want to attend class, it was important to ask the students what their *primary* mode of attendance is. Of the 165 Stats 412 students during Winter 2018 who responded to the survey, 17.6% (29 students) primarily attend in person and 77.0% (127 students) primarily attend via the remote stream. The in-person numbers seem fairly accurate based on Miller's observations during teaching, and remote streaming numbers seem reasonable based on analytics from Wowza—the average number of unique viewers through the class meeting on Wednesday, March 7 is 109.3, with median 107. The standard deviation was 21.5 unique viewers, but was 8.6 unique viewers when not including the first class meeting of the term when not all students were aware of the opportunity to stream lecture. Students have accessed the remote stream from all over the United States as well as from Canada, China, Russia, Taiwan, and the United Kingdom.

It appears that not having the lecture recordings available forces students to attend class in real time. Making the decision not to have recordings was difficult, because some students really did use the recordings in the "right" ways (e.g., missed a class due to an interview or other appointment, not a morning person and preferred to listen to the recording at another time of day, reviewing for an exam and/or while working on homework). One student this term has good reasons for recorded lectures being posted: "I think that Dr. Miller should really bring back lecture recordings in addition to the remote stream. As someone who always attends lecture in person, even in my classes that offer recordings, I find this sort of tool very helpful. In the rare cases where I cannot come to class, I don't have to get notes off of a friend, I can simply watch the lecture recording. Also, if I missed a small part of notes because the instructor went too fast, I can just find what I missed back in the recordings later on." Although this student may use the video recordings

as a supplement to lecture rather than a replacement, data from this course (Fall 2017 vs. Winter 2018 semesters) and prior research at other universities (Drouin, 2014) suggest most students do not and that video recordings hurt attendance which in turn may hinder academic performance.

Specifically, the increase in synchronous remote attendance this term is promising and may override the desire of the students who want recordings. The students in Stats 412 now find it easier to attend class. Here are some examples in their own words:

- I don't have to get up as early and I can learn stats in pajamas with a big fuzzy blanket and hot cocoa.
- I can focus better sitting by myself as opposed to sitting in a lecture room. Able to take notes from the comfort of home.
- I have physical training that ends at 0800 and having the remote stream allows me the ability to shower and eat breakfast before I remotely attend. I would not be able to do this if I had to be there in person.
- Flexibility in where I listen to class (all my classes are on North campus so this system makes it easy for me to stay there all day and cuts out on travel time).
- Watching the lecture via the remote stream allows me to take screenshots of the slides and write down the important notes after the lecture. During the lecture, I can therefore focus on the material and concepts, instead of focusing on transferring the notes onto my page.
- No excuses for [not] watching lecture. If I wake up late I still have the ability to watch the lecture without being behind.

This does not mean that there are not issues with HyFlex, some of which are technical in nature and some of which concern students not knowing their own learning styles/ideal learning environments. Consider the following comments from students:

- There are minor issues with the stream that can lead to missing things.
- Delays, technical issues, easily distracted on my computer.
- Cannot have a one on one interaction with the professor.
- You can't talk to fellow classmates to clear up any questions.
- Although there is a link to ask questions, it is not as easy as asking question as it is if I attended in person.
- I don't get to see the professor smile.
- I sometimes don't pay attention as well as I would in person.
- Paying attention is harder. First exam suffered probably due to my direct disconnect with the material.

Students have made suggestions for improvement of the model:

- Maybe also have a streaming version of office hours for students that cannot make it to your office for whatever reason. You could potentially answer questions and work out examples on the screen so everyone can learn from other students' questions.
- Stream slides and front of classroom where you are teaching from. I believe it provides better interaction when you can see the teacher. And as you are fully aware, try and figure out a way to get the tech to work more fluidly.

Even though there are some issues and HyFlex is not perfect, our experience with HyFlex in Stats 412 has been promising this term. We will continue to address the issues and concerns of the students while also pursuing the best technology to operate a HyFlex environment. One student brought up a suggestion that is on our wish list already: "It would be great if we could ask questions on the website that the stream is displayed on. For example, by typing them on a sidebar. This would make asking questions faster and easier, and also mean we could see what others have written and their questions/comments." We also need to consider the availability of lecture recordings.

CHALLENGES

One challenge we currently have is technological in nature—our current setup has a lag in the stream that causes about a 30-second delay between when Miller speaks or writes and when remote students hear what was said and see what was written. This is somewhat frustrating for the

students, the instructor, and the IT people involved in the project. We continue to seek solutions to this issue.

As more and more students choose to attend via remote stream, administrators may be tempted to increase enrollment in the course to fill the classroom. This enrollment brings with it its own issues (students may feel lost in a larger class), but it brings even more problems if administrative help is not afforded to the instructor as the class size continues to grow. As mentioned earlier in this paper, Stats 412 has been growing significantly in the past few years (from about 250 students during the 2013-2014 academic year to about 500 students during the 2017-2018 academic year). Because Stats 412 does not have a lab component associated with it, the only additional help for the faculty member is in the form of two graders for the course. The number of graders has not increased to match enrollment.

CONCLUSION

Our claim is that the HyFlex model is excellent for courses that have the structure of a course like Stat 145/1450 at Ohio State and even better for a course like Stats 412 at Michigan. HyFlex may not be appropriate for courses structured like Stats 250 at Michigan. The affective benefits to students are of the most import to us as researchers, because we want to teach our students in a way that best works for them. We look forward to continued study of the HyFlex model at Michigan. Our hope is that interest in the model expands beyond department and beyond the university. As one student said, "I think there is still a lot of research that needs to be done on blended/hybrid learning. I do not mind having a hybrid class every now and then, but I would be sad if all my classes were hybrid, because it is so important for me to be around people. I think it is extremely important to consider both the learning and mental health outcomes of these learning environments, to create the optimal experience for students, and I am excited to see the outcomes of experimenting with these new learning methods." We are too.

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