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Making a Case for HyFlex Learning in Design Engineering Classes

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Introduction

The onset of the still-ongoing Covid-19 pandemic resulted in a rapid switch to remote learning, with passing months seeing the rise in popularity of *HyFlex learning*, a learning model which supports synchronous in-person and remote class attendance [1], thus accommodating students who want to attend class in-person while also providing attendance options for those students who might otherwise miss class for health or personal reasons. However, over the past year or so, public perception of the threat of the different strains of the Covid-19 virus has reduced and consequently, a large number of institutions have reverted to in-person modes of instruction that prevailed prior to the start of the pandemic (e.g. [2], [3]). The near-total suspension of HyFlex instruction has been met with little protest in the academic community, with only a handful of researchers speaking in its favor (e.g. [4]–[6]).

In this paper, we align our voices in support of HyFlex learning, arguing that the Covid-19 pandemic taught us the valuable lesson that HyFlex learning options should always have a place in education, as we particularly make a case for our field of design engineering education. Through empirical research consisting of semi-structured interviews with students who took HyFlex design engineering classes over the past year and as instructors of such courses, we compare the HyFlex learning model to its in-person counterpart. We demonstrate that HyFlex learning is equally effective in delivering on intended course outcomes as in-person education and does not compromise on student learning and performance, while additionally functioning as a crucial accessibility component for students. In our experiences, HyFlex learning not only affords class participation to students with injuries or illnesses that prevent in-person attendance, but also accommodates various emergent extenuating circumstances that would have otherwise resulted in student absence. Finally, we find that components of HyFlex learning such as closed captioning and non-disruptive private chats positively contribute to student learning. We make a case for HyFlex learning to be a necessary and valued component of design engineering education and universal design for learning, calling for the allocation of more resources and research into improving it for students and instructors alike.

HyFlex Learning

The phrase ‘hybrid learning’ has been used in a variety of different meanings in education over the past few decades. Generally speaking, it refers to any combination of in-person and online learning methods in courses. Literature from the early 21st century (e.g. [7]–[10]) referred to courses that used in-person instruction combined with online components such as submission of assignments and discussion forums as hybrid. With the growth of the role of the Internet in university education and the advent of online learning management systems

such as Blackboard and Canvas, such online components became the norm in every course, thus necessitating a change in the meaning of the phrase 'hybrid learning'. Hybrid learning has been described as a combination of technical problem solving skills and social awareness to identify problems [11], some combination of in-person and online instruction [12], and predominantly in-person courses with some form of asynchronous online component [13]. After the onset of the Covid-19 pandemic in 2020 and the shift to fully online learning in universities, many courses returned in 2021 to some form of class structure with *synchronous* in-person and online components [5]. In order to distinguish this mode of instruction from hybrid learning as defined above, such a synchronous modality is called 'HyFlex learning', which we study in this paper.

Over the past three years, HyFlex learning has been studied through several different motivations and fields of education. Within fields such as mathematics [14], physics [6] and the performing arts [15], HyFlex learning models have been known to improve learning outcomes and student-teacher relationships. However, a lot of studies that portray HyFlex learning in such a positive light do so in contrast to completely online learning, which was almost the primary mode of instruction worldwide in universities during the height of the Covid-19 pandemic. Although some researchers (e.g. [16], [17]) appreciate HyFlex modalities for the consideration of student choice, few are eager to utilize it as the prevalent form of instruction going forward, especially as an alternative to purely in-person learning. Through our work, we argue that HyFlex learning is equally and perhaps more effective than traditional in-person instructional format at both the undergraduate and graduate levels, additionally providing evidence-based arguments for HyFlex learning providing important accessibility considerations that make the course content and experience more equitable.

Methods

Course Structures

We provide empirical evidence from semi-structured interviews with students in four HyFlex learning design studio courses, both at the undergraduate and graduate levels. Two courses that focused on inclusive design, hereafter referred to at the undergraduate and graduate levels as BID and MID, respectively. The 10-week courses were introductions to designing, prototyping, and evaluating inclusive user interfaces that should meet the needs of a diverse range of users—such as older adults, users with visual, cognitive, or motor disabilities, and users who are D/deaf or hard of hearing. Building on basic concepts in human-centered design which centers user experience in interface design [18], students were taught about design exclusion and barriers to use, as well as research and design methods by which these can be overcome. The courses consisted of 34 (BID) and 37 (MID) students each, and included a multi-week, team-based participatory co-design project that would meet the needs of a diverse range of users—such as older adults, users with visual, cognitive, or motor impairments, and users who are deaf or hard of hearing. Both classes were project-based, where students were placed into

groups based on their interests. Students were asked to interview their participant and identify current pain points with existing artifacts, and then co-design solutions to improve user experience. The spirit of participatory co-design was strongly recommended, asking students to avoid designing *for* their participant and instead design *with* them. The second author of this paper was the instructor for both courses, teaching BID in Fall 2022 and MID in Spring 2022.

The other two were introductory user-centered design courses, hereafter referred to as BUCD and MUCD at the undergraduate and master's levels respectively. The courses explored the user-centered design cycle, with an emphasis on the importance of developing and applying design processes and strategies. Students were encouraged to think like a UCD practitioner and carry out activities key to the design process, gaining hands-on experience in user research, ideation, prototyping, and evaluation of their own designed object (an app, a tool, a website, a physical artifact, etc.). In the group project, students were encouraged to use research and generative design to develop and explain an underlying rationale for the end product. Over three quarters, the classes averaged to 34 students (BUCD) and 37 students (MUCD), respectively. The first author taught BUCD for four quarters: Fall 2021 (co-taught with second author), Winter 2022, Spring 2022, and Fall 2022. The second author taught MUCD in Fall 2022.

The courses were taught in 'flipped classroom' formats [19], whereby students were given readings to complete before class time and the instructors spent the first half of classes going over readings and fielding student questions. A significant portion of daily class time was also spent on small-group reading discussions, based on design sketches or short discussion questions that students brought to class. Finally, about 40% of class time was dedicated to group work, where students could get into their groups and discuss their quarterlong project.

All courses were taught mainly in a HyFlex format, whereby the instructor would be physically present in the departmentally-allocated classroom but maintain a Zoom [20] link and allow students to join class that way. In terms of technology usage, course instructors used a laptop computer, a built-in projector in the classroom, and when not in a hybrid classroom, an OWL [21] 360º videocamera and microphone. Some class sessions were held 100% on Zoom. Slides and other visual content employed in class would be screen-shared and projected with captions turned on, so that both in-person and remote students could follow along.

For this study, we also consider student performances in courses, both in aggregate and individual formats, to assess student fulfillment of course objectives. Across all four courses, students performed exceptionally well, with median class GPAs all being above 3.8. All students who participated in this study (detailed below) did well in their respective courses, meeting course objectives and producing strong work. We do not report any identifiable information or specifics of student scores, in accordance with federal law and best practices of such research.

Participants and Recruitment

To conduct this study, we waited until the end of each quarter past the grade deadlines to avoid students fearing that participating (or declining to participate) in our study would impact their grades. We then sent out mass emails to the class listservs, informing them of the objectives of the study and soliciting their participation by inviting them to take a short survey. Survey respondents who volunteered to be interviewed about their course experiences were contacted by the first author to ask for their availabilities for a compensated 30-45 minute Zoom semi-structured interview. Prior to the start of each interview, the interviewer obtained interviewees' consent to record the conversations and use their comments for this paper after taking appropriate steps to anonymize any identifiable information. The contents of the survey and semi-structured interview protocol were all submitted to the Institutional Review Board at the authors' home university prior to the start of the study, and the study was deemed exempt.

The semi-structured interviews began with asking participants about their history of having taken HyFlex learning, fully in-person and fully virtual courses at the university level, and how they compared different learning modalities. We then asked specific questions about the course (BID/BUCD/MID/MUCD) they were enrolled in, inquiring about their experience both in general and in context of their own projects. In particular, we inquired in detail about their decisions to attend class by availing one of the offered modalities on any given day, and how they made such choices. Interviewees spoke at length about the HyFlex nature of the course aiding or detracting from their course experience and achieving learning outcomes, both instructor-specified and personally determined. We asked how the group dynamics and project work were affected by the HyFlex structure, and whether this caused any awkwardness or miscommunication, or otherwise impacted their abilities to express themselves freely. We sought retrospective feedback for how their course experience could have been improved and ended with a question on whether they would prefer having the HyFlex modality were they to do the course over again. In total, we conducted 13 interviews for this study. Information about participants is shown in Table 1, along with pseudonyms, course and mode of attendance.

Table 1: List of Interview Participants

Participant #	Pseudonym	Course Attended	Primary Mode of Attendance
P1	Alice	BUCD	Virtual
P2	Ravi	BUCD	In-Person
P3	Ashten	BUCD	Both In-person and Virtual
P4	Gary	BUCD	Both In-person and Virtual
P5	Jenny	BUCD	Both In-person and Virtual

P6	Andriy	BUCD	Both In-person and Virtual
P7	George	MID	Virtual
P8	Morgan	BID	Both In-person and Virtual
P9	Thomas	BID	Both In-person and Virtual
P10	Warren	BID	Both In-person and Virtual
P11	Winston	MUCD	Both In-person and Virtual
P12	Jerry	MUCD	In-Person
P13	Garfield	MUCD	In-Person

Qualitative Coding

We analyzed the transcripts of the interviews by performing content analysis [22] on them. In qualitative coding, we simultaneously listened to the audio of interviews alongside the text of the transcripts to avoid missing information that might have been mistranscribed by Zoom's auto-transcription. We identified a series of key themes, presented below and substantiated with salient examples from interviewees.

Analysis

Comparing Modalities

Each of our interviewees spoke to positive experiences in HyFlex design studio courses. Coming out of an entire year in fully remote classes, participants were quick to talk about the online format not working out for them.

"Fully online just doesn't work for me, there's no sense of collaboration or being able to overhear stuff from other groups that ends up helping my thinking." - Ravi.
" I can't concentrate in online classes. Design work just doesn't happen that way, especially stuff like affinity mapping or prototyping."- George.
"I find it easy to check out in online courses, there's no sense of accountability to each other to absorb class content or actually do productive group work." - Warren.

Participants also spoke about the HyFlex nature of courses offering them an important transition out of fully remote learning. For students who had gotten used to being at home and scheduling back-to-back meetings and classes, HyFlex courses made them think about planning their days and commutes to attend classes in-person while providing a fallback in case their plans went awry on any given day (Jenny). Such a modality also provided a positive experience with

respect to the rest of their courseloads, as many other classes went back to fully in-person at the first available opportunity, asking them to perform a turnaround to how they learned over the past year (Andriy, Winston and Jerry).

In general, each of our participants appreciated the HyFlex modality for having the option to choose remote attendance on any given day, while otherwise planning on being in-person as their default mode of class participation. They spoke about their preference of the HyFlex format as opposed to the fully in-person format, while the others also mentioned how HyFlex affordances were useful and how their absence would have inhibited their course experience. Though a few interviewees did note that participating online on some or most days did result in some drop of attention levels, no one reported feeling any awkwardness in small group conversations or miscommunication due to the HyFlex format.

Accessibility Considerations and Accommodations

Perhaps the first and most prominent reason behind our choice to adopt a HyFlex format for the aforementioned design studio courses were considerations for accessibility and accommodations. In this study, our participants validated this choice.

"At the start of the quarter, I injured my leg and that made it impossible for me to regularly attend class in-person. While I had to drop out of a lot of my classes, BUCD being HyFlex made it possible for me to still take the class and gain the experience." - Alice.

Alice further spoke about the HyFlex mode allowing them to participate completely virtually in a course they were required to take that quarter in order to stay on track for graduation. Their project work saw them get together with other students who also indicated a preference for remote attendance, as they collectively designed one of the strongest projects in the class. During the last week of class when students presented their projects, Alice attended class in-person after undergoing some recovery and rehabilitation, as their team displayed a well-designed physical prototype of a room that could better handle HyFlex meetings.

"Spring 2022 was a hard quarter, because my best friend and grandmother both passed away, and I attended their funerals. Were class not hybrid [HyFlex], I would've needed to take an incomplete." - George.

George spoke about enduring a challenging quarter when they took MID. They spent several days away from class due to attending the funerals of their best friend and their grandmother. Beyond the days of the funeral, George talked about spending time at home and with family, away from the physical space of the classroom. They appreciated having a HyFlex option to participate in MID, because it allowed them to participate at their own pace and engage with course content and group work.

Finally, Jenny and Warren both mentioned being appreciative of the HyFlex format because it allowed them to travel out of town to be with their family to celebrate religious and cultural holidays. They talked about the HyFlex nature of the courses allowing them extra time with their families during celebrations, because they could attend classes remotely. On the other hand, they continued, they missed classes in other courses that only offered in-person attendance during such times. Such appreciation was also expressed by Garfield, who said that the HyFlex modality allowed them to travel and still attend class.

Individual, Circumstantial Choices

Our participants also spoke about appreciating the HyFlex nature of the courses and the flexibility it afforded on a day to day basis, which allowed them to attend class on days when extenuating circumstances would have prevented them from being present in-person. Morgan mentioned living almost an hour's drive away from the University, and on a snowy day when roads were blocked and their vehicle could not reliably make the commute, they appreciated the opportunity to attend class from home without risking their safety. Similar sentiments were expressed by several other participants such as Ravi, Andriy, Winston and Jerry, who attended class from home when they felt unwell or unable to be present in-person. As Ravi put it,

"I appreciated the flexibility of the course such that it allowed me to make a decision on a day-by-day basis about how I would attend class, depending on my circumstances and how the group was attending too. I much prefer this over fully in-person or fully remote days." - Ravi.

Leveraging HyFlex Affordances

Finally, our interviewed students mentioned that specific affordances of HyFlex learning and the way that we utilized technology in class positively impacted their course experience. Garfield mentioned that while they attended class almost entirely in-person, they were appreciative of the fact that the instructors ran a Zoom room behind the slides projected on the screen because it activated Zoom's auto-captioning feature. They went on to state that the availability and constant presence of live captions (albeit imperfect) aided their comprehension of instructors' lectures. The availability of captions, both during classes and in the increased usage of subtitled media during peaks of the pandemic, was appreciated by Garfield and other participants. Additionally, a few students such as Ashten and Morgan mentioned that in cases when they were in-person and their group mates were remotely attending via Zoom, they could sign in to the Zoom session and interact with them via DMs, without being disruptive or appearing as if they were on their phones during class.

Discussion

We observed a strong student preference for HyFlex learning as the mode of instruction in their design studio courses. Though most participants attended their respective courses in-person, they detailed their appreciation for the flexibility that the HyFlex format afforded them to choose remote attendance any given day, as personal circumstances dictated.

Our HyFlex learning format was largely designed to provide a more equitable access to class to all of our students across the four courses. In a social and political environment that increasingly pushed and continues to push for a "return to normal" and reverting to practices that were prevalent prior to the start of the Covid-19 pandemic [23], we intended to design a classroom that would make participation accessible to all students while still meeting course objectives. In our assessment of these courses, our personal reflections and indications from student performances and grades reflect that our version of the courses still met established learning objectives and taught students the key skills they needed to get from these courses. In such a light, we evaluate the success or failure of our HyFlex modalities.

The first and perhaps strongest win for our HyFlex structures was that it allowed students such as Alice and George to attend class as they found themselves in situations where it became impossible to be physically present in the classroom. They mentioned how other courses they were enrolled in were less accommodating of their circumstances, which led to miss classes or drop out. In particular, George's case is salient because their extenuating circumstances arose multiple times in the middle of the quarter which required them to travel out of town, but the HyFlex modality made it such that we did not pressure them to return to class at the earliest. The ability to join class remotely likely provided George with time to be in the company of people they could emotionally recuperate around. Similarly, Jenny and Warren appreciated being able to spend additional time with their families in times of celebration and religious/cultural holidays, and still be able to attend class. Such 'informal' accommodations also allowed them to avoid going through official channels and University services for getting accommodations, which might often be slow and backed up under high volumes of requests. These, combined with other experiences of students where the option of joining remotely meant that they could safely attend class when they were unwell or did not have reliable travel options, speaks highly of the equity provided by the HyFlex modality. Such a modality allowed us to practice ethics of care towards students' physical and emotional wellbeing in designing our classrooms [24], while also providing them the agency to participate in classes at their own comfort and engagement levels.

The HyFlex format did more than just provide students with an opportunity to join class via Zoom on days that they were unable to attend in-person. The HyFlex modality meant that we could leverage Zoom and all of its affordances even within the classroom, none more so than the live captions. Humans' increased dependence on the availability of captions due to higher consumptions of subtitled media content during peak periods of the pandemic [25] meant that

live closed-captioning during classes proved to be an important accessibility consideration for all students. Though we did not capture such perspectives within our interviews, such live captioning might also have been critical to accommodate students with auditory processing disabilities or who are D/deaf or hard of hearing and rely on lip reading for comprehension, which would have become impossible due to the instructor being masked.

Though this study was focused on four design studio courses, nothing in these findings suggest that they could not extend to other types of courses. Some of the key ways in which design studio courses differ from lecture-style courses, such as in-class group work or physically building prototypes, were affected due to the HyFlex modality of the course. Our participants reported smooth course experiences while also meeting learning objectives more than adequately. While some engineering education courses, such as chemistry labs, might have a strong case for requiring in-person attendance to meet course objectives, evidence from prior research (e.g. [17], [26], [27]) suggests that a HyFlex model can be successful in several different courses across various levels of education. We believe that the coursework and structures of a wide majority of engineering courses should not necessitate such a requirement, and that a HyFlex course modality can make giant strides towards equitable access to education for all students, without compromising on the achievement of learning outcomes and course objectives.

Having said that, we emphasize that our recommendations for maintaining a HyFlex structure for design studio courses must be applied at institutional or departmental levels, and should not place the load on individual instructors. While we leveraged departmental resources such as the Owl, which undoubtedly saved us expenses, we invested extensive additional time outside of coursework prep in setting up and testing the technology for smooth facilitation of the HyFlex experience. We did so because we personally decided to, but the labor of figuring out and designing HyFlex studio courses should not fall upon instructors who do not ask for it. Rather, departments and universities should provide the necessary support and infrastructure to facilitate such courses to those who choose to provide such a modality, without the amount of physical and technical labor required becoming a deterrent. This is especially important considering that often, such labor disproportionately falls upon professors and instructors with marginalized identities, as they shoulder higher emotional and technical burdens to accommodate student needs in comparison to their more privileged colleagues [28], [29]. In future extensions of this work, we intend to examine such instructor labors to elucidate this point further.

Limitations and Future Work

We acknowledge an important limitation of our work, with respect to power distance between instructor and student. It is possible that the students who participated in this study demonstrated self-selection bias, in the way that they only signed up to participate because they had entirely or mostly positive experiences in their respective courses. As much as we tried to eliminate the power distance between student and instructor, it is probably the case that students

who were dissatisfied with their course experiences did not feel empowered to discuss such grievances with us and therefore did not sign up to be interviewed. We believe that a stronger version of this study could be conducted by a student in a HyFlex course, combining their personal experience with interviews of peers and instructors. Such a study would address this power distance issue, and might lead to more honest conversations.

With the observable shift of several universities in the US and other countries gradually shifting to a primarily in-person mode of education over the past few months, we intend to continue making our case for incorporating HyFlex elements in course designs. We plan on extending this study across more students and more classes at our university, as we build a more compelling narrative for our call.

Conclusion

The Covid-19 pandemic taught many lessons to individuals and organizations worldwide, and one of the most important lessons for educators and universities is that HyFlex learning as a modality of instruction is doable for several different types of classes. In this paper, we demonstrate that such a modality in design studio courses achieves learning outcomes while providing flexibility and accommodating individual accessibility needs that strive towards equitable access to education. We contribute towards growing scholarship towards more equitable practices in our classrooms (e.g. [4], [5], [16], [17], [30]) by advocating for the continuation of HyFlex learning as an offered mode of instruction for design studio courses, and hope that the engineering education community continues to recognize its valuable contributions.

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