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Investigation on Students' Educational Experience with HyFlex Instruction Model in Two Engineering Courses

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Abstract

Due to the COVID-19 pandemic, educators all around the world searched for effective ways to continue teaching. Although switching to online learning seemed to be the safest and most appropriate method at the time, the virtual setting is inadequate for providing active learning. Hands-on learning is indispensable especially for engineering programs. In Fall 2020, synchronous online mode was augmented with HyFlex instruction for the first time. HyFlex is short for Hybrid learning and Flexible course structure. The HyFlex course model provides students with the following options to choose from: (1) face-to-face, (2) online, or (3) a mixture of face-to-face and online. For the HyFlex instruction, instructors at the current institution divide the class into groups to follow social distancing in the classrooms, which reduces the number of students present in the classroom to roughly half of its maximum capacity. Depending on their assigned group, students take turn attending face-to-face classes in with the instructor present. When the student is not physically in the classroom, they join the class through Zoom meetings.

In this study, our focus is on the HyFlex instructional model that our school implemented recently. Two engineering classes selected for this study are Electricity and Magnetism, a sophomore level Engineering Physics class, and Fluid Mechanics, a junior level class. Both classes have students from various engineering disciplines. The study group includes 103 students in Physics and 48 students in Fluid Mechanics. It should be noted that in Fall 2020, the semester started a week earlier and all the breaks were removed to encourage students to stay on campus in an effort to prevent spread of COVID-19. As the end of the Fall semester was approaching, both instructors noticed that some students were having more difficulty with the HyFlex instruction in comparison to traditional face-to-face instruction. These difficulties included not being able to complete assignments on time, lack of motivation, and having trouble obtaining and retaining information. To investigate this further, a survey was administered to study the influence of the HyFlex instructional model combined with the shortened semester on the mental and emotional health of the students. Documenting the advantages and disadvantages of this model will help us to shape a better instructional model that could be used more widely in the future. The instructors will discuss their observations on the HyFlex instructional model as well as feedback for future semesters.

Introduction

With the onset of COVID-19 pandemic, most educational institutions moved to online and/or Hybrid-flexible (HyFlex) instructional models. The HyFlex model was first developed and introduced by Beatty [1] in 2006 as a way to address physical space constraints and to better accommodate non-traditional students (with various levels of knowledge background and/or working full-time). It is defined as multi-modal learning that combines face-to-face instruction with online teaching. In the HyFlex model, students have the choice to decide whether they want to attend the class in person in a typical classroom setting or online (synchronous or asynchronous), or both, on any class day [1]. According to Beatty [1], there are four main pillars of the HyFlex model.

1. *Learner's choice:* students decide how they want to attend the course (face-to-face or online).
2. *Equivalency:* instructor provides learning activities that are suitable for all types of learner's choices.
3. *Reusability:* capturing and sharing learning activity artifacts with all learners. This could be classroom lecture recordings, discussion boards, and sharing presentations.
4. *Accessibility:* all the course materials, software packages, technological resources should be made available to all students.

Some schools have been using the HyFlex model before the COVID-19 pandemic. With support and leadership of Beatty, San Francisco State University has been implementing the HyFlex instructional model in several Instructional Technology MA program courses since 2006. In 2013, Miller et al. performed a pilot study at Ohio State University on a Statistics course using the HyFlex model [2]. Their work showed that the mode of attendance (online vs face-to-face) did not have a noticeable impact on student's overall learning or individual grades. They also conducted survey at the end of the semester asking students to identify their preferred attendance type after this experience. The survey results showed that 5% of the students preferred face-to-face with no instructional technology, 57% favored face-to-face lectures with instructional technology and 38% chose completely online lectures.

In Fall 2020, HyFlex instruction with synchronous online model was implemented throughout our college. Unlike the HyFlex model described above, students were divided into groups and they interchangeably attended classes in face-to-face and online mode throughout the semester. Some students were given permission to attend the classes completely virtual only if they obtained a prior approval from the college due to medical reasons. In this model, a group of students attended classes in person while the rest joined them through Zoom meetings. Each classroom is equipped with a camera system so that students joining the class online could see the physical classroom, other students, and the instructor. Zoom camera focus settings were adjustable and the instructors were in charge of control. Classes were live streamed and the lecture recordings were made available to students through Learning Management Software - Canvas. During class, instructors interacted with all students through polling, discussion questions, and breakout rooms. On campus, as a safety measure, mask wearing and social distancing were reinforced at all times. In addition to the new model of instruction, the college also decided that there would be no breaks during the semester to discourage students from traveling and spreading COVID-19. Most facilities, such as the cafeteria, gymnasium, bookstore and library, were available for use with COVID-19 restrictions. There were several outdoor performances (concerts and theater) that were still possible through the use of social distancing. However, most of the campus social events, including club activities, took place virtually.

York College of Pennsylvania switched to online/remote education in March 2020. A sudden transition to remote education during Spring 2020 and then to the HyFlex instruction model in Fall 2020 has been stressful and challenging for both students and faculty. There has already been an increase in depression, anxiety, and stress among young adults in recent years before the COVID-19 pandemic [4] and now several studies have shown that COVID-19 caused a further increase in these conditions [3], [5], and [6]. Kazmi et. al. [3] investigated the impact of the COVID-19 pandemic on depression, anxiety, and stress. 1000 respondents living in India,

with an age range of 15-50, participated in this study by completing a survey. The survey uses Depression Anxiety and Stress Scale (DASS- 21). DASS is a widely used tool that reliably assesses levels of depression, anxiety, and stress. The authors concluded that younger participants, in the age range of 21-25 years old, are highly susceptible to depression, stress, and anxiety due to uncertainty about job prospects, fear of infection, and economical problems [3]. Cao et al. [7] performed a study on mental health of undergraduate students during the COVID-19 epidemic in China. The survey questionnaire included the 7-item Generalized Anxiety Disorder Scale (GAD-7) in addition to questions about demographics. With 7143 participants, their survey results show that 24.9% of respondents experienced some degree of anxiety. Living at home with parents, having a stable income, and living in urban areas were factors reducing anxiety while delays in academic activities, living away from parents, and economic difficulties increased their anxiety. Son et al. [8] looked into mental health of undergraduate students attending a large public university in Texas during COVID-19. Their survey looked at students' general stress levels using the Perceived Stress Scale-10 (PSS). With 195 participants, their survey results show that 71% of the participants noticed an increase in stress and anxiety during the pandemic. The examples of highly ranked stressors can be categorized as worrying about their own health and the health of their loved ones, difficulty with concentration during online classes, irregularity in their sleep pattern, social isolation, transition to online classes, and change in living conditions. The current study was performed during transition into online education. Our goal in this study is to identify the highly ranked stressors resulting from the HyFlex instructional model followed in Fall 2020. To achieve this goal, the authors prepared a survey similar to Renner and Mackin's College Undergraduate Stress Scale (CUSS) [9]. CUSS developed by Renner and Mackin consisting of a list of 51 items (stressful events a traditional age college student can experience) and their corresponding stress ratings. Since CUSS includes stressors specific to college students, we decided to include some of those items in our survey. Furthermore, additional stress sources specific to COVID-19 are incorporated. Knowing the sources of stress will help us to develop strategies to reduce it as many colleges are planning to implement the HyFlex model during Spring 2021.

In this study, we have two goals: (1) identify the sources of stress for sophomore and junior level undergraduate students during the Fall 2020 semester and (2) investigate the efficacy of HyFlex instructional tools used in both classes in regard to students' learning and reducing stress levels during the Fall semester.

Class Information and Structure

Engineering Physics

Engineering Physics - Electricity and Magnetism, is a 5-credit sophomore level calculus-based physics course and is required for most engineering majors. There were a total of 103 students enrolled under 5 lab sections during the Fall 2020 semester. All labs were on Thursdays and lectures were on Mondays, Wednesdays and Fridays. For the lectures, the enrollment was split to into 3 sections consisting of 42, 40 and 21 students. The same classroom with a seating capacity of 48 (before COVID-19) was used for both labs and lectures. With the pandemic restrictions, classroom seating capacity was dropped to 24. Two lecture sections had 41 students and seating was optimized to accommodate 23 students every day with the condition that every student must attend class face-to-face at least one day of the week. To make a fair arrangement of this schedule, a short survey was administered in the beginning of the semester. All students

were present in-class for hands-on lab experience since the enrollment on each lab section was less than 23. Thus, all students attended physics classes in person at least twice a week.

Several active learning methods were used in this class. Fundamentals of Physics textbook [11] was the supplemental textbook to the instructor's notes for prior reading, homework assignments and self-study. The Exploratory Physics textbook [12], which emphasizes on active learning, was used as a workbook during class time in the Physics - Mechanics course which is one of the prerequisites for Electricity and Magnetism. The details of this book was published elsewhere [13]. The Exploratory Physics textbook reinforces critical thinking by using a problem solving strategy in every problem. This strategy focuses on analysis of the problem and deeper understanding of the solution process. It starts with identifying the problem by stating what is *Given,* and what to *Find*. Then, *Assumptions* are identified, which helps students to focus on the key factors that may change the solution. This is followed by making an *Estimation* and forming a *Plan* by stating the physics laws/principles and equations. The next part is putting all the information together in the *Solution* part. After solving the problem, students discuss key points and check whether their answer makes sense under the *Reflection* part. This problem solving strategy makes students better critical thinkers by having them focus on how to solve the problem rather than simply getting an answer [14]. The examples of this process is illustrated in every in-class problem and students practice it during workout problem sessions and homework assignments.

In each class, a new topic is introduced briefly and most of the class time is spent on discussions and problem solving. Due to the pandemic limitations and shortened semester, the instructor decided to prepare several 10-minute video clips for each class to explain the concepts and solve problems. Supplemental video recordings were also implemented for labs as an option for visual learners and students in quarantine. Students watched the videos online before the class. With this approach, more practice problems were completed in class. In addition, instructors played music during problem solving to reduce stress and boost motivation.

The class materials were delivered using powerpoint slides and recorded on cloud via Zoom. Each class contained many multiple-choice questions. Before the pandemic, instructors used clicker questions in-class to collect prompt feedback and clarify any misconceptions. Each class section shares the clicker remotes and because of that, clickers were not used during the pandemic. Instead, Canvas quiz platform was used for questions.

Fluid Mechanics

Fluid Mechanics is a junior level engineering class. In Fall 2020, there were 48 students enrolled. The class has 3 lecture credits and 1 laboratory credit. The lecture portion of the class is on Tuesdays and Thursdays while there are laboratory sessions on Tuesdays, Wednesdays and Thursdays. During laboratory sessions, due to the hands-on nature of the labs, the instructional model was face-to-face. To accommodate hands-on learning, 4 laboratory sections were formed. At each section, there were 12 students enrolled. If the student has a virtual attendance approval from the college, in that case they are able to join the lab session though Zoom meetings. Having a Zoom camera setup in the laboratories allowed students to observe the lab experiments synchronously. This was a very important tool as several students contracted COVID-19 and/or was in contact with a person who had it and needed to switch to remote learning during the semester. For the lecture sessions, classrooms equipped with live streaming capacity were used.

The classroom had a 32 student seating capacity before COVID-19. Now the same classroom has a capacity of 19:1 student/faculty ratio to promote social distancing. To accommodate that the students were divided into multiple groups and each group took turns in attending the class in person. If the student was not scheduled to attend the class in person, they joined the class through Zoom meetings. Class attendance and participation were mandatory.

Instructors used several instructional tools during Fall semester. These tools are summarized below.

- The Fluid Mechanics course Canvas page included information about syllabus, schedule, Zoom meeting links for the class and office hours, lecture notes, video recordings, homework, quizzes, and exams. Lecture notes were organized by topic and date.
- Instructors explained course expectations and structure at the first day of the class, and continued to remind them throughout the semester. For example, homework was collected on Fridays and quizzes took place on Tuesdays.
- Each class session was recorded during Zoom meetings. In addition, instructors prepared online videos of problem solutions and class demonstrations. These videos were made available to students to watch outside the class on Canvas page.
- During lectures, instructors delivered the course material by using powerpoint slides. A document camera was facilitated to show property tables and used in place of a whiteboard for explanations. The whiteboard in the classroom was not used during lectures other than to project lecture slides onto it. This was decided based on the image quality especially for students joining the class via Zoom meeting.
- During in class problem solving, instructors demonstrated how to solve example problems using the same problem solving strategy used in physics class (outlining problem definition with given and identifying what to find, listing appropriate assumptions and coming up with a solution plan/method, solving the problem, and reflecting on the results).
- The assigned textbook is the 8^{th} edition of Fluid Mechanics by Frank M. White [15]. Throughout the semester, reading materials were assigned from the textbook and additional online resources were posted on Canvas to reinforce understanding of certain concepts.
- Instructors continued to have office hours. Before COVID-19, instructors were available to help students in their office space during office hours. During Spring 2020, with a sudden switch to an online instructional model, office hours were held through Zoom meetings. In the Fall semester, during the HyFlex instructional model, instructors continued to have online office hours (Zoom meetings) and also were available to help students in the classroom once a week.
- Weekly reflection papers are implemented as a discussion board item on Canvas. Students comment on what they learned well from that week's class and what they have difficulty understanding. This was used as a formative assessment and diagnostic tool.

Method

In this study, participants are all undergraduate students with age range between 18 to 25 years old. Course instructors emailed the survey link to engineering students in sophomore level Engineering Physics and junior level Fluid Mechanics classes. The survey generated uses an

anonymous link. Anybody having that link can take part in the survey. Students who completed the survey followed the link provided in the email and gave consent for data collection. 151 students were invited to participate and 87 students gave consent and completed the survey (57.6% response rate). The survey group mainly consists of students in mechanical, civil, electrical, and computer engineering majors. There was no class credit or financial reward for completing the survey. The participation was voluntary and their responses were kept anonymous.

Survey Information

The survey administered is developed by two course instructors who implemented the HyFlex teaching model during Fall 2020. In the survey, questions were divided into four sections:

1. demographics data,
2. current level of stress and its contributors,
3. HyFlex instructional tools and their effectiveness, and
4. suggestions/recommendations from students to make their learning experience more effective.

Demographics data included gender information, living conditions (on campus vs off campus), and academic year (sophomore or junior). The stress level and contributors question is similar to the College Undergraduate Stress Scale (CUSS) developed by Renner and Mackin [9]. CUSS is broadly used as a way to determine overall stress in a college student's life over 1 year. In the questionnaire, we also included stressors specific to COVID-19 pandemic such as concerns about getting sick, concerns about family members getting sick, and change in social activities and eating habits. Students reported how much these stressors contributed to their stress during Fall semester by using a 5-item Likert rating scale ranging from 'not at all' to 'a great deal'.

In the HyFlex instructional tools question, students rated the methods implemented by both faculty by using a 5-item Likert scale ranging from "not at all useful" to "extremely useful". Some of these methods are outlined under each course description. In average, survey participants spent 3-5 minutes to complete the survey. The copy of the email sent to students can be found in Appendix A. The survey was administered in Qualtrics Software.

Results and Conclusions

The study group includes 103 students in Physics and 48 students in Fluid Mechanics. According to class enrollment data approximately 10.0% of students in Physics class and 12.5% of students in Fluid Mechanics class are female. In the United States, it was reported by Roy [10] that 21.9% of the students who earned a bachelor's degree in engineering were female in 2018. Out of 151 students invited to participate, 87 students (33 junior level students and 54 sophomore level students) completed the survey. The demographics data shows that among that participant group of college students, only (10/87) 11.4% were female which is similar to class enrollment percentages in engineering. In terms of living conditions, most of the students (66/87, 75.8%)

chose to live on campus while 24% lived off campus and commuted to school during Fall semester.

Highly ranked stressors during Fall 2020 semester

The survey asked students to identify the stressors from the list provided to them and also indicate how much each of these stressors contributed to their stress level during the semester with a 5-item Likert scale (a great deal stressor, contributed to stress a lot, a moderate amount of stressor, contributed to stress a little, and not at all a stressor). The stressors included in the list are a sense of overload in school, lack of sleep, failing a class, missing classes, financial difficulties, change in social activities and eating habits, concerns about getting sick, concerns about family members getting sick, and other factors. In Figure 1 and 2, the top six stressors are illustrated with the percentage of students who rated them as 'a great deal stressor or contributed to stress a lot', 'a moderate amount of stressor', and 'a little or not at all a stressor'. The original survey has a 5-item Likert scale. In the figures, for clarity some of the items were combined to form a 3-item Likert scale.

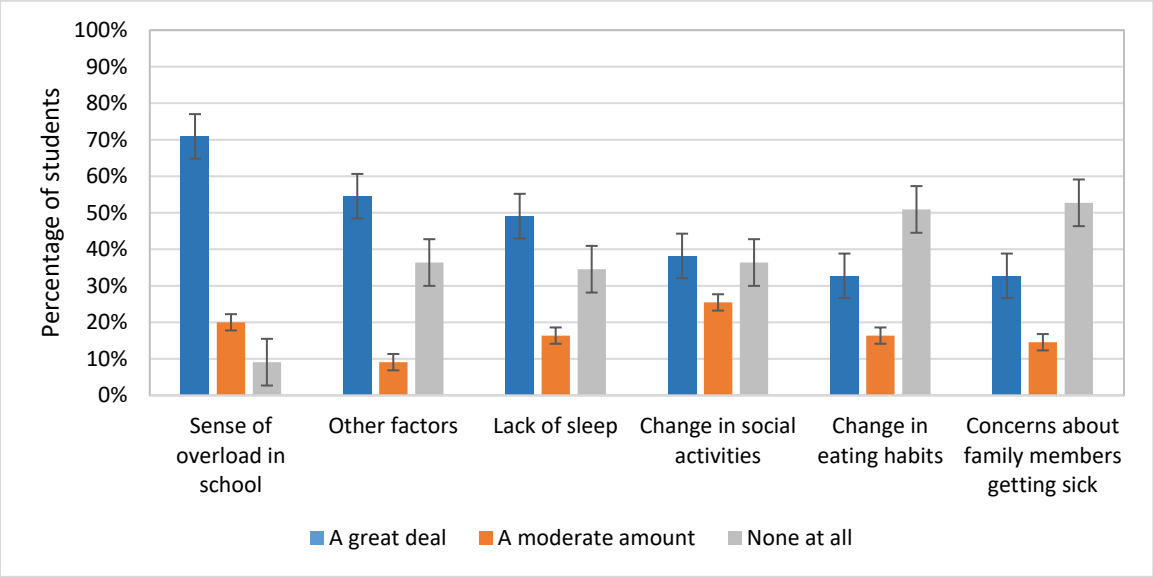

Figure 1: Survey results illustrating stressors for sophomore level engineering students

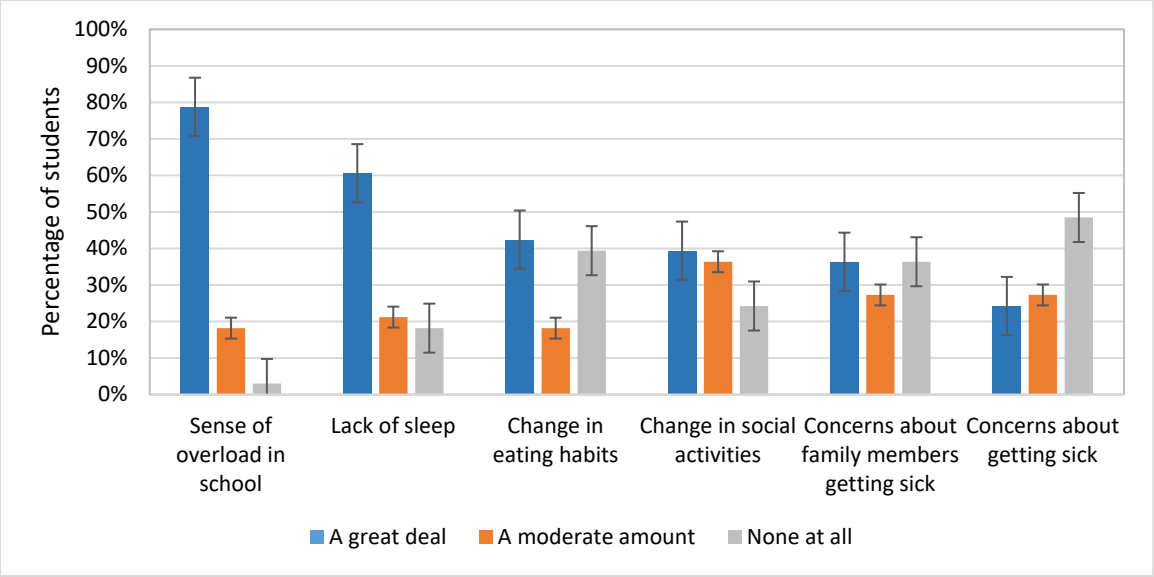

Figure 2: Survey results illustrating stressors for junior level engineering students

The sense of overload is the highest ranked stressor for both sophomore and junior level engineering students. The percentage of participants reported a sense of overload as a great deal of contributors to their stress at sophomore level and junior level are 71% and 79% respectively. The Fall semester in 2020 started a week earlier and all the breaks were removed to encourage students to stay on campus until the semester ended in an effort to help prevent the spread of COVID-19. Many participants in the survey commented that a combination of shortened (fast-paced) semester and lack of breaks were the main factors causing the sense of overload in school.

Over half of sophomore engineering students (55%) listed other factors as the second highly ranked stressors whereas the 61% of juniors chose lack of sleep. During the Fall semester, juniors are taking two engineering laboratories in addition to Fluid Mechanics, two core and two general education classes. For junior engineering students, this has always been one of the most challenging semesters. With the changes implemented due to COVID-19 such as lack of breaks and fast-paced semester, instructors observed that some of the students had difficulty managing their time and workload. As a result, they experienced lack of sleep. The other factors listed by sophomore students are working full time in addition to school, lack of breaks, anxiety disorders, and learning disabilities. The summary of these additional factors with student comments are included in the next section.

The third highest ranked stressor is lack of sleep for sophomores and change in eating habits for juniors. Slightly less than half of sophomore engineering students (49%) ranked lack of sleep as an important stressor. The other important stressors for sophomores with their response percentages are change in social activities (38%), change in eating habits (33%), and concerns about family members getting sick (33%). For juniors, COVID-19 specific stressors such as change in eating habits (42%), change in social events (39%), concerns about family members getting sick (36%) and concerns about getting sick (24%) were considered as a great deal of contributors to their stress.

The stressors that influenced them the least are financial difficulties, missing classes, and failing classes. Almost 80% of participants in sophomore engineering class and 72% in junior level ranked missing classes as the least important contributor to their stress during the semester. In the HyFlex teaching model, students attended face-to-face classes in the classroom or they joined the class through Zoom meetings. It was observed that availability of recorded class videos on Canvas and having multiple platforms for class attendance such as face-to-face and Zoom meetings reduced the stress of missing classes.

Student's comments on additional factors that contributed to stress

In the survey, students also wrote comments on additional factors that contributed to their stress level during the Fall 2020 semester. In the proceeding part, responses from all participants are grouped based on the theme of the comment. In addition, a percentage of participants commented on each theme is reported.

Lack of breaks and shortened, fast-paced semester - (21%)

"How crammed the semester was due to the shorted semester"

"Lack of time for all classes' assignments"

"Everything for each class seemed to be due around the same time which made things difficult"

"Lack of breaks during the semester, not being in class everyday"

"Lack of breaks were the largest stressor for me. Normally, a break can help me completely rejuvenate, but with our compressed semester, any days off I took to recuperate caused me to fall behind with my classwork"

"Prior health issues being agitated due to the increased workload and lack of any form of break."

"No breaks, not even a day off."

"Lack of breaks throughout semester"

"The removal of breaks. It is very easy to burn out if your workload is heavy which I was not previously used to."

"The amount of things that were on my plate this semester were a lot to manage. It was challenging when every break that I wanted to take, I knew I had a bunch of other things that I should be doing with that time. I found it challenging to ever take a true break."

"I think that not having the breaks and still having baseball and everything else that was going on added to my stress over the semester. There were some nights where I was going to bed around 12:30 and waking up again at 5:00 to finish up work because it just felt like there was not enough time in the day to complete everything."

"I joined a fraternity organization this semester and I had no free time at all this semester. The combination of joining the organization and the increased difficulty of all my classes took a toll on my sleep schedule and stress levels"

"This is the second time I am taking PHY260, so there was a lot of pressure to pass it this time and with all my other classes on top of it was a lot. It was so hard to submit assignments on time. I have not had much time to relax or even apply for co-op in the spring. There was just a lot this semester."

"Just overload"

"A lot of work was pushed onto the students to learn and complete the work on their own."

"Overloading of work between all classes."

"The workload / adjustments made because of COVID"

COVID 19 specific stressors - (6%)

"Being all cooped up in our dorms"

"I have only 3 people I interact with anymore, and one of them is my roommate"

"Normally I would try to employ breathing techniques to remain calm, however this semester, wearing a mask made it difficult to employ such practices."

"Just the lack of knowledge due to COVID"

"Not being able to leave"

Having a learning disability such as anxiety, ADHD - (6%)

"My ADHD really hurt me at the beginning of the semester. During the beginning of the semester my ADHD medication stopped working because I got too old for it, so it didn't help me focus in school. I was also in between doctors at the time so I wasn't able to get another prescription for any other type of medication."

"I do have ADHD and Anxiety, and I am pretty good at keeping myself in task and successful but sometimes even just being around people who are stressed, behind, failing, is enough to trigger a panic attack just because I do understand what they are going through but I don't have the energy this semester to help people as much as I usually like to"

"I have anxiety"

"The fear of failing a class or more and having to take another semester, or dropping college, or not being able to pay for an extra semester and finish college. Also feeling like I have learning issues due to all the other factors affecting the learning during these times."

"I have PTSD that causes insomnia so I hardly sleep. But this semester it truly had an effect on my exams"

Difficulty in staying focused during synchronous Zoom classes – (3%)

"It is so easy to not pay attention at home my lack of focus added to the stress of classes"

"It was difficult to find time to have one-on-one help with professors"

"Very hard to learn this way."

Student's comments/suggestions on ways to reduce stress

Survey participants were also asked to write comments/suggestions that would help to reduce stress during upcoming semesters. Their suggestions are included below.

Include a day off/a break, slowing down, assign less work /allocate more time to complete tasks

"A day off with no added videos or any assignments to take care of built into the schedule from the start."

"The no breaks in the semester runs everybody ragged. While I understand the urgency, skipping out on built in breaks isn't helpful"

"I think that with the hyflex semester it is hard because there are no breaks. These are really times that the students and teacher have to decompress, and without them it is hard to relax more than a day or a little more."

"Just some breaks to reduce burnout"

"My issue with hyflex was the course speed we went through really quickly and if you fall behind it's a lot harder than most semesters"

"I felt everything was very rushed which things just piled up in every class that it got stressful. I think slowing down and hitting only the major points is key for a semester like this"

"Probably nothing other than less work but that isn't really possible."

"More time to complete homework, less chapters per test. If all the different classes could coordinate to have tests on different days."

"This class in particular wasn't the most stressful other than the stress of trying to pass this time. It was mostly a combination of all the classes together that really made it stressful. I had stuff due like everyday and it was hard to get enough sleep and hand my assignments in on time."

"Maybe give one "assignment pass" for the year because some weeks it got really hectic and that could have been very nice."

"Less homework, either only assign the write outs, or only the Wiley problems"

"Working on timing of big assignments between classes"

Having more office hours

"Office hours are always a plus"

"Something I noticed was when I went to a professor's office hours, I would leave it feeling very relieved. Remote learning allows for a disconnect between the students and professors, and by attending office hours one on one with the teacher, it did not make me

better at the course material but it made me less reluctant to do the coursework while under pressure and stress."

Other

"Allow more possibilities for taking the labs or exams online. Additionally, provide practice exams to help studying stress."

"I think it would be fun to have a peer mentor system where you can partner with someone who needs help and then you guys can study together. Especially with quarantine it can be very difficult to meet new people"

"Not doing school in a middle of a pandemic"

"In all honesty I thought this semester went really well."

HyFlex instructional tools and their usefulness in regards to student's learning and reducing stress levels

One of the questions in the survey focused on the students' perspective on the usefulness of HyFlex instructional tools used. We asked the question "Considering the HyFlex instruction used this semester, how useful did/would you find the following in regards to learning and reducing stress levels? Skip the part if it doesn't apply to you." with a likert scale options Extremely useful (1), Very useful (2), Moderately useful (3), Slightly useful (4), and Not at all useful (5).

Table 1 summarizes the results of the answers to this question. The instructional tools are reordered in the table from extremely useful to less useful based on the mean value. The lesser the mean value, the more useful the instructional tool.

Table 1: Analysis of HyFlex instructional tools/aids based on their usefulness during the Fall 2020 semester.

	Mean Value	**Standard Deviation**	**Variance**
In-class problem solving	1.51	0.69	0.48
Organized Canvas course	1.62	0.82	0.68
In-class instruction	1.68	0.82	0.68
Lecture notes on Canvas	1.69	0.89	0.79

Reducing some of the regular load (compared to previous semesters)	1.82	1.1	1.2
Shared Zoom class recordings	2.11	1.13	1.27
Office Hours	2.41	1.09	1.19
Available rooms/space for Zoom sessions (on days you were not scheduled to be in class)	2.5	1.22	1.48
Online (Zoom) instruction	2.83	1.02	1.04
Pre-class videos	2.87	1.17	1.38
Starting the class with positive quotes/advises	2.99	1.44	2.06
Starting the class with music	3.02	1.4	1.95

Most Useful Instructional Tools

Students' feedback showed that several instructional tools used in the HyFlex model made a positive impact on engineering students' learning experience as listed in Table 1. The most useful instructional tools are in-class problem solving sessions, organized Canvas page, in-class instruction, and lecture notes on Canvas.

1. *In-class problem solving.*
   Most students favored in-class problem solving as the most useful tool during HyFlex learning. All students, in-class and on Zoom, solved problems during class time. In-class problem solving refers to those problems with the guidance of the instructors. This tool is usually the most valued aspect of engineering courses even before the pandemic since students learn with practice and practicing problem solving skills is the most useful regardless of the type of instructional model. Application of the concepts is essential for engineering students. This motivates students to relate with real life situations and keeps them engaged both during face-to-face and remote learning.

2. *Organized Canvas course.*
   Daily class pages were created on Canvas as a module and they were kept consistent for each class. This allowed students easy access and created multi-ways to reach the course information. Having organized Canvas Course is crucial for easy access to course information without the need of an instructor being present. The daily pages included the following:

- Announcements/Reminders of the day
- Prior Reading sections from the textbook
- Class Notes in Videos with YouTube playlist link
- Zoom Links for each section
- Zoom Recordings to be updated when links available
- Class Notes in pdf form
- After Class Quiz Questions link for students
- Handout links to files
- Homework and Discussions link for students to get help from anyone in class
- Office Hours and tutoring hours with Zoom links

3. *In-class instruction.*
   Face-to-face instruction in class. Interaction between students and instructors is indispensable for both parties.

We also would like to note that having in-class office hours was also beneficial for students, as the majority of students did not participate in Zoom office hours. Students preferred to get help on homework or laboratory assignments in class - right before and/or right after the class. To increase participation during office hours, we switched our office hours to after/before class time in the classroom or via Zoom for the Spring semester.

Least Useful Instructional Tools/Aids

Some tools were not as favored as others but this was expected and the instructors reviewed their plans for future semesters.

1. *Pre-class videos.*
   Most students did not see the value in watching pre-class videos. Students would benefit more from this if they had watched the pre-class videos. Some students did watch them and commented that they learned the concepts better since it prepared them for the upcoming class. Most students need more motivation to watch pre-class videos. Unless there are incentives given to the students that contribute to their overall course grade, preparing pre-class videos is time consuming for instructors. If the reader considers implementing pre-class videos, we would suggest that the video length is kept between 5 to 10 minutes. The longer the video length, the less likely the students will watch them.

2. *Starting with music and positive quotes/advises.*
   Some students seem to find starting class with music and/or positive quotes/advice slightly helpful. Doing this doesn't require much effort for instructors and helps at least a few students so the authors are continuing to do so in the Spring semester.

Students' suggestions/comments on what would help with their learning experience

Exam help and instructional tools

"Specific problem solving related to exam questions"

"Create a study guide for exams, specific to the exam, not just workout problems"

"More projects/homework so help students who don't do as well on exams"

"I think more point opportunities and less weight on the tests would ease a lot of stress going into them"

"Maybe for zoom sections, if the professor can find a way to share the board while solving the problem while talking, as well as recording it instead of the computer screen. It gives a better sense of understanding for the cases where the professor points or gestures and those gestures are not shown on the zoom screen."

"Make sure I go back and look over the material after class, which I think the after class quizzes helped with."

"Fun demonstrations"

In conclusion, during COVID-19 pandemic, every sector including universities were tasked to explore options to continue to operate. The HyFlex instructional model was the option implemented in Fall 2020 at York College of Pennsylvania. This model offers several advantages and some drawbacks. Main advantages of the HyFlex instructional model at the current institution can be listed as

- *Being able to interact with instructors and classmates similar to face-to-face.*
  In comparison to online education, the HyFlex (combining face-to-face with synchronous online) model allowed students to interact with the course instructors and classmates in the classroom, which promotes a better learning environment.
- *Keeping hands-on aspect.*
  During the HyFlex, students took turns to attend the class face-to-face. This enabled hands-on learning activities such as performing experiments, collecting and analyzing data in small teams.
- *Having attendance flexibility.*
  During the Fall semester, some students could not attend the class in person due to several reasons (such as contracting COVID-19, being in contact with someone who tested positive, or being sick) and synchronous online through Zoom meetings was an essential tool for those students to stay connected to the class.
- *Increased accessibility.*
  All classes and laboratory exercises were recorded through Zoom meetings. Students had full access to course materials, class recordings, and additional laboratory demonstrations. Both Canvas course page and google shared drive were utilized to improve accessibility.

The drawbacks of the HyFlex model at York College of Pennsylvania were mainly shortened semester without any breaks, increased sense of overload, anxiety and stress. Survey results showed that a sense of overload and lack of sleep were among the top three stressors for both sophomore and junior level engineering students. The least important stressors were financial difficulties, missing classes, and failing classes. To overcome some of these drawbacks,

there will be two separate break days added to the academic calendar during Spring 2021. In addition, instructors collaborated with other course instructors to coordinate major deadlines.

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Appendix A

The copy of the email sent to students is shown below.

Hello All,

I am writing to request your participation in a *survey that investigates how to improve students' learning experience during HyFlex instruction.*

The purpose of the survey is to collect information on HyFlex instruction model (stress level factors and learning experience). The goal is to come up with a collection of methods/techniques that improve students' learning experience and mental wellbeing and finally share these methods with other faculty members.

Your participation in this survey is completely voluntary and all of your responses are anonymous. There is no reward for participation. All of your responses will be kept confidential. They will only be used for statistical purposes.

The survey will take approximately 5 minutes to complete.

To participate, please click on the following link:

If you have any questions about this survey, or difficulty in accessing the site or completing the survey, please contact us.

Thank you in advance for providing this important feedback.
