

Assessing the Effectiveness of a Flex Model for a Sustainability Course in the COVID-19 Learning Environment

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Dr. Tony Kerzmann's higher education background began with a Bachelor of Arts in Physics from Duquesne University, as well as a Bachelor's, Master's, and PhD in Mechanical Engineering from the University of Pittsburgh. After graduation, Dr. Kerzmann began his career as an assistant professor of Mechanical Engineering at Robert Morris University which afforded him the opportunity to research, teach, and advise in numerous engineering roles. He served as the mechanical coordinator for the RMU Engineering Department for six years, and was the Director of Outreach for the Research and Outreach Center in the School of Engineering, Mathematics and Science. In 2019, Dr. Kerzmann joined the Mechanical Engineering and Material Science (MEMS) department at the University of Pittsburgh. He is the advising coordinator and associate professor in the MEMS department, where he positively engages with numerous mechanical engineering advisees, teaches courses in mechanical engineering and sustainability, and conducts research in energy systems.

Throughout his career, Dr. Kerzmann has advised over eighty student projects, some of which have won regional and international awards. A recent project team won the Utility of Tomorrow competition, outperforming fifty-five international teams to bring home one of only five prizes. Additionally, he has developed and taught fourteen different courses, many of which were in the areas of energy, sustainability, thermodynamics, dynamics and heat transfer. He has always made an effort to incorporate experiential learning into the classroom through the use of demonstrations, guest speakers, student projects and site visits. Dr. Kerzmann is a firm believer that all students learn in their own unique way. In an effort to reach all students, he has consistently deployed a host of teaching strategies into his classes, including videos, example problems, quizzes, hands-on laboratories, demonstrations, and group work. Dr. Kerzmann is enthusiastic in the continued pursuit of his educational goals, research endeavors, and engagement of mechanical engineering students.

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ASEE Environmental Engineering Division

Abstract

The COVID-19 global pandemic has suspended conventional operations in engineering education and forced changes that will inform our practice for years to come. The need for engineering educators to adapt course designs in short time frames amidst the compounding uncertainty of safety protocols, operational postures, and accreditation requirements is unprecedented and still evolving. As teachers update classroom technology, content, rubrics instructional schemes and cohort assignments there is much uncertainty about how this will affect our students. This paper attempts to evaluate the impact on students of transitioning to a Flex-Model during the global pandemic of COVID-19. Specifically, to gain insight on students' perception on the interaction within the new model, their learning experience and well-being within the Sustainability course.

Using principles from HyFlex literature, our R1 university created a flexible instructional model. This Flex-Model is designed to accommodate in-person and remote instruction for professors and students alike. Instructors were encouraged to flexibly incorporate face-to-face class meetings with opportunities for remote students to participate using video conferencing technology (i.e. blended course delivery). Instructors were asked to leverage synchronous online activities, and asynchronous online content as appropriate to the size of their class, availability of suitable classroom space, content, and course structure (e.g., lecture-based, discussion, recitation, project-based, lab, studio) while considering the location of the students and access to on-campus resources.

This research strives to evaluate the effectiveness of the Flex-Model through the lens of the student experience in a Sustainability course due to its interdisciplinary nature and that all 6 of our engineering departments were represented within the class population. The course is a topics course requiring weekly readings, discussions, assignments, and quizzes. The class roster consisted of 92 students (10 graduate students) with two of the co-authors serving as instructors. Data from student surveys conducted before, and during the Fall 2020 semester were analyzed. Survey questions included both qualitative and quantitative prompts.

Introduction

The global COVID-19 pandemic has caused a drastic shift in the higher education learning ecosystem and has changed the means by which course materials are delivered in the classroom. Educators currently have little information regarding the effectiveness of this new educational environment, especially when it comes to discussion-based courses [1]. Although studies are few, preliminary research suggests due to COVID-19, higher education will see academic performance suffer as well as increased dropout rates [2].

Many educators around the world have been required to redesign their courses to accommodate a fully online teaching environment. There is evidence that shows many academics encountered challenges in effectively facilitating the online classroom experience and lacked the necessary understanding of information technology to provide a smooth transition to online learning. Many educators were also not well-versed in the online pedagogical understanding needed to design an engaging online experience [3].

There are a number of challenges in the transition to online learning for the professors, but there are just as many, if not more, challenges for the approximately 200 million post-secondary students, who have also had to transition to new learning environments in a short period of time [4]. Students found it difficult to adjust to different online learning styles from different professors [5]. For instance, some professors recorded themselves in front of a whiteboard and posted the video on the Learning Management System (LMS), while maintaining a traditional homework, quiz, and exam schedule, while other professors produced interactive live synchronous learning sessions that included student engagement, online assignments and projects that engaged students in the higher levels of Bloom's Taxonomy [6].

Other student challenges included access to the necessary internet connectivity, for tasks such as online video conferencing, poor faculty to student communication, additional responsibilities and distractions from their physical learning space being located in their home, and lack of access to devices such as laptops and tablets [7-9]. The lack of basic needs in some households also provided a major issue to some students. Basic needs such as food, shelter, clean water, electricity, healthcare and security may not be available to some students in their homes [10,11]. Many students rely on the resources provided by higher education institutions to provide for their basic needs. Without these resources, a student may be stuck addressing their basic needs and cannot move on to address higher-level needs [12].

Higher education students have experienced a rapid transition from in-person to online learning, combined with lockdowns, social distancing and in many cases the need to move their home. These drastic changes in lifestyle along with lack of social interactions and uncertainty about the future have led to increased rates of stress, anxiety and depression in post-secondary students [13-15]. With all of these other factors, some of which have a higher level of priority, students are experiencing a reduction in motivation in online learning [16-18].

It is clear that COVID-19 has negatively impacted the entire global population on many levels, including in higher education. In an effort to minimize any additional anxiety for students, the University of Pittsburgh adopted an education model that allowed students to participate in online learning in a way that provides some level of comfortability. Based on the HyFlex course

design model, the FLEX@PITT model provides students with a mix of synchronous and asynchronous activities where students are able to participate in a livestreamed videoconference class or watch an asynchronous recording of class [19]. From the instructional perspective, educators have the option to deliver the course in-person or remotely, while also providing both synchronous and asynchronous resources for students [20]. The FLEX@PITT model has been successful in transitioning educators and students alike to online learning but is not without challenges. The course design, preparation, and technological aptitude required of the instructors were the biggest hurdles in implementing the model. For students, who are generally more technologically savvy, the challenges tended to be associated with peer interactions, team projects, socializing, study groups, and screen fatigue.

This research is designed to evaluate the effectiveness and preferences of the students in an online HyFlex Sustainability course. The student population polled in this study are from a sophomore-level Issues in Sustainability course which is highly dependent on classroom discussion. Discussion within the classroom is one of the most difficult elements of an in-person class to emulate in an online environment. In an effort to engage students in higher levels of learning (as shown in Figure 1), the course was designed to enhance online interactions through discussion boards, student video assignments, and live video conference discussions which incorporated smaller discussion groups [21]. The instructors also prioritized professor to student communication with weekly announcements providing students with course updates, important information, due dates, changes to the schedule and classroom availability.

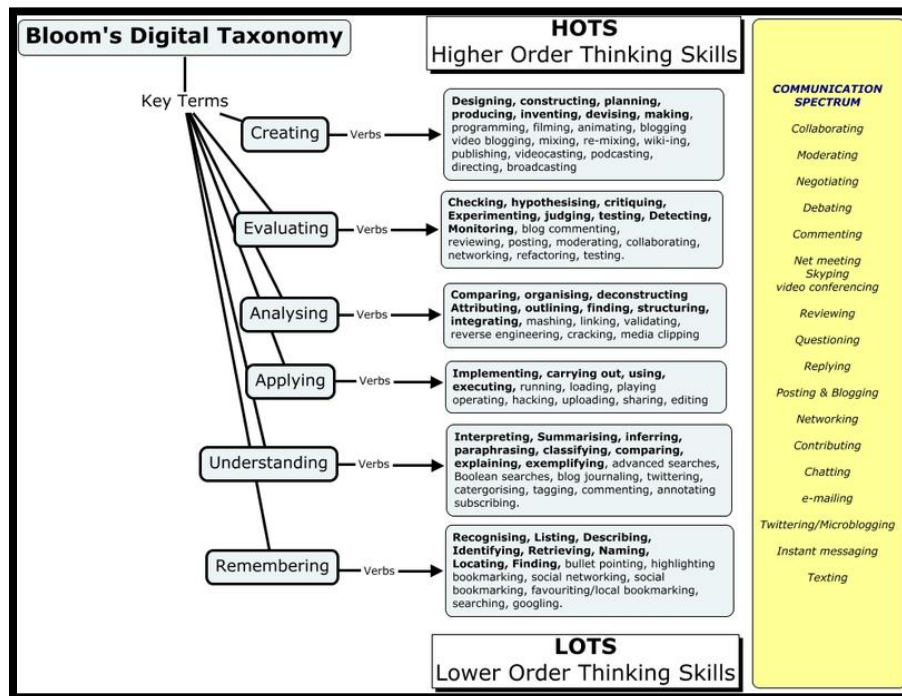


Figure 1: Bloom's Digital Taxonomy [Churches]

One of the unique aspects to the course facilitation was that the course was offered as both online and in-person. The majority of the students chose to attend class online via a live Zoom videoconference feed. A smaller portion of the students attended class in a traditional classroom

using social distancing and following the university COVID safety protocol. The students who were in-person were able to communicate in real-time with the online students and faculty through the use of the classroom audio visual equipment, as shown in Figure 2. The class syllabus and requirements for the same for students attending online and in-person.



Figure 2: In-Person Classroom and Zoom Online Synchronous Instruction

Methodology

A sophomore sustainability course with two sections and 92 total students (10 of which were graduate students) was taught in the fall semester of 2020. This was the first time that this course had been taught online and was the first time that the instructors and students had participated in a course using the FLEX@PITT model. The students were surveyed to evaluate their level of agreement with the course and to gather data regarding their comparative rating of the online HyFlex course as compared to their previous experiences with traditional in-person courses. The course is a topics course which included weekly readings, discussions, assignments, and quizzes. Both of the instructors of the course are also authors and the 2 Qualtrics surveys were administered during the Fall 2020 semester [22]. The survey questions included both qualitative, open-ended questions and quantitative, Likert-scale questions, and are shown in Appendix A. The results from these surveys and the comparison between the two surveys are shown below in Table 1-6.

Results

The initial set of questions evaluated student perception of the instructor, logistics and expectations of the course. The results provide a base-line to establish the influence of the instructors' abilities to design and teach a course with the Flex-Model. There are 8 items that fall into three general categories namely, the

- Instructor competency
- course organization and rigor
- communication and interactions.

Questions provided were Likert scale questions in the range of "Extremely Dissatisfied" to "Extremely Satisfied" on a five point scale. Results from the student pre-survey can be found in Table 1 below. Note that the students are rating their level of agreement having experienced Pitt's transition to remote learning in March 2020 and, having been able to engage all course elements for this course at the time of the survey.

For each of the 8 items, all averages were found to be above 4 except for *Level of interaction with your professors* and *Level of interaction with your classmates/peers*. Additionally, the statistical modes for all items were at a 4 with the exception of *Your instructor's use of technology* which was at a 5.

Table 1: Pre-Survey Results for Student Agreement of Course Elements in the Flex@Pitt model

Pre-Survey						
Please select the level of your agreement with the following statements	Extremely Dissatisfied (1)	Dissatisfied (2)	Neither Satisfied nor Dissatisfied (3)	Satisfied (4)	Extremely Satisfied (5)	AVERAGE (Data bars relative to lowest value)
Your instructor's availability	0	4	12	40	29	4.11
Your instructor's use of technology	0	0	3	37	45	4.49
Course materials (readings, presentations etc.)	0	6	11	42	26	4.04
Academic rigor of the course	0	2	17	44	22	4.01
Level of interaction with your professors	0	5	18	37	25	3.96
Level of interaction with your classmates/peers	1	9	22	41	12	3.64
The frequency of communication by instructors	0	4	12	42	27	4.08
Rate instructor(s) overall teaching effectiveness?	2	2	5	41	38	4.26

The results from the post-survey are listed in Table 2. The pattern and trend remain the same, however, there is an overall positive shift in satisfaction across all categories. Specifically, the average score for each individual element increased in the post surveys. In addition, the statistical modes increased for two of the categories, namely *Frequency of Communication by your Instructors* and *Rate Instructor(s) overall teaching effectiveness*.

Table 2: Post-Survey Results for Student Agreement of Course Elements in the FLEX@PITT model

Post-Survey						
Please select the level of your agreement with the following statements	Extremely Dissatisfied (1)	Dissatisfied (2)	Neither Satisfied nor Dissatisfied (3)	Satisfied (4)	Extremely Satisfied (5)	AVERAGE (Data bars relative to lowest value)
Your instructor's availability	0	2	6	44	36	4.30
Your instructor's use of technology	0	0	0	36	52	4.59
Course materials (readings, presentations etc.)	0	2	6	46	34	4.27
Academic rigor of the course	0	1	9	46	32	4.24
Level of interaction with your professors	0	1	17	42	28	4.10
Level of interaction with your classmates/peers	0	10	22	32	24	3.80
The frequency of communication by instructors	0	1	7	38	42	4.38
Rate instructor(s) overall teaching effectiveness?	0	1	4	35	48	4.48

The variability between the pre and post surveys is best illustrated in Table 3. All of them show a positive shift supporting the idea that student expectations for instructor competency, course organization and rigor, and communication and interactions can be met with the Flex Model course delivery scheme.

Table 3: Percentage Difference Between Pre- and Post-Surveys

Positive (+) % difference means students had a higher level of satisfaction in the Post-Survey as compared to the Pre-Survey	Percentage Variation from Pre- to Post-Survey
Your instructor's availability	3.8%
Your instructor's use of technology	1.9%
Course materials (readings, presentations etc.)	4.7%
Academic rigor of the course	4.5%
Level of interaction with your professors	2.8%
Level of interaction with your classmates/peers	3.2%
The frequency of communication by instructors	5.9%
Please rate instructor(s) overall teaching effectiveness?	4.3%

The second set of questions given to the students focused on their perception of their learning experiences and well-being. The importance of this next set of questions was that it shifted their evaluation away from their expectations of the Flex Model and the instructor's ability to utilize it toward a reflection on how the shift from traditional in-person classes has impacted their perceived ability to learn, retain concepts, and personal well-being.

The pre-survey results for the experiential set of questions can be found below in Table 4. The Likert scale ranged from 1 to 7 which correlated with the labels "Much Better In Person" to

“Much Better Online”. The averages for item found in the last column all skew toward a preference for in-person classes as the more positive experience for understanding, retention, confidence and personal well-being. It is important to note that the statistical modes for all 7 items listed were neutral (i.e. 4 or “about the same”).

Table 4: Pre-Survey Results for Student Experience of Course Elements in the FLEX@PITT model

Pre-Survey								
Please comparatively RATE your traditional in-person class experience in Current Issues in Sustainability versus an online course.	Much Better In-Person (1)	Moderately Better In-Person (2)	Slightly Better In-Person (3)	About the Same (4)	Slightly Better Online (5)	Moderately Better Online (6)	Much Better Online (7)	AVERAGE (Data bars relative to lowest value)
Your understanding of course Concepts	5	7	18	50	5	1	1	3.57
Your Retention of course Concepts	10	8	27	36	3	2	1	3.28
Your Overall Learning	10	12	30	30	3	1	1	3.13
Your confidence in learning as a student	15	13	22	31	3	2	1	3.05
Your mental well-being as a student	21	21	13	25	1	4	2	2.82
Your physical well-being	18	16	15	22	6	4	6	3.21
Your emotional well-being	18	14	20	24	3	4	4	3.09

The post-survey results highlighting the student learning experience and well-being can be found below in Table 5. Averages across each item and category decreased since the pre-survey indicating that student perception of their well-being and ability to learn was hindered.

Table 5: Post-Survey Results for Student Experience of Course Elements in the FLEX@PITT model

Post-Survey								
Please comparatively RATE your traditional in-person class experience in Current Issues in Sustainability versus an online course.	Much Better In-Person (1)	Moderately Better In-Person (2)	Slightly Better In-Person (3)	About the Same (4)	Slightly Better Online (5)	Moderately Better Online (6)	Much Better Online (7)	AVERAGE (Data bars relative to lowest value)
Your understanding of course Concepts	4	10	30	36	4	2	2	3.45
Your Retention of course Concepts	12	20	22	28	2	2	2	3.02
Your Overall Learning	15	16	22	27	4	3	1	3.02
Your confidence in learning as a student	14	16	22	27	5	3	1	3.07
Your mental well-being as a student	27	14	18	16	6	1	6	2.85
Your physical well-being	25	17	13	16	6	6	5	2.99
Your emotional well-being	21	20	20	17	1	5	4	2.86

The variability between the pre/post experiential surveys is best illustrated in Table 6. The largest changes in averages show that student learning experiences and well-being prompted a stronger affinity for in-class learning, specifically, for the “your retention of course concepts”, “your physical well-being”, and “your emotional well-being”.

Table 6: Percentage Difference Between Surveys Conducted in October and November

Positive (+) % difference means students provided a higher rating for Online in the Post-Survey as compared to the Pre-Survey	Percentage Variation from Pre- to Post-Survey
Your understanding of course Concepts	-1.7%
Your Retention of course Concepts	-3.6%
Your Overall Learning	-1.5%
Your confidence in learning as a student	0.3%
Your mental well-being as a student	0.5%
Your physical well-being	-3.1%
Your emotional well-being	-3.3%

Conclusions

The data showed that while instructors were able to redesign the interdisciplinary course using the Flex Model there was a significant impact on their learning and well-being. Along with instructor observations, the data analysis presented some revealing conclusions from the student perspective. Prior to the semester, student responses were highly focused on anxiety about safety and uncertainty about the level of online engagement in the class experience. Survey results during the semester indicated that while the online content, virtual classes, organization, and faculty efforts were rated very positively, there remains a very strong preference for in-person experiences that were inadequately reproduced virtually. Among the student comments, there was a strong correlation to the lack of personal engagement, increased distractions, decreased motivation, hesitancy to engage in class discussions and the lesser ability to develop rapport with peers and professors.

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Appendix A: Issues in Sustainability Survey Questions

Please openly reflect on things that went well in the class over the course of the semester.

Please select the level of your agreement with the following statements					
	Extremely Dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Extremely Satisfied
Your instructor's availability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your instructor's use of technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Course materials (readings, presentations, speakers etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Academic rigor of the course	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Level of interaction with your professors	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Level of interaction with your classmates/peers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The frequency of communication by your instructors	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

