The Flipped Classroom During the Remote Period of COVID: Student Perceptions Compared to pre-COVID Times

In this study, flipped instruction in an undergraduate engineering course in the “COVID“ online, remote environment was conducted and compared to onsite flipped instruction (i.e., pre-COVID) to explore potential changes in student perceptions. Student perceptions were gathered via survey instruments and investigated further through instructor interviews. This analysis was done at three universities and made possible by extensive research with the flipped classroom at these three schools as part of a previous NSF-funded study between 2014 and 2016. Results gathered in the online remote setting suggest positive changes in student perceptions of flipped instruction compared to the onsite environment, including the decreased perception of the “load“ imposed by the flipped classroom and the “effort“ required. Some desirable outcomes remained unchanged in the remote setting. The recent and emerging literature has suggested the remote, online environment dictated by the pandemic may be beneficial for flipped teaching and learning. These and other findings from conducting flipped classrooms at three engineering schools in the online environment are presented, including perceptions of the classroom environment (via the College and University Environment Inventory), benefits and drawbacks identified, student motivation levels, and perceived learning.

Keywords: Flipped classroom, numerical methods, COVID, online, remote

1. Introduction

Flipped instruction and learning have been the subject of much classroom-based research. At times, the flipped classroom has been associated with mixed student outcomes and perspectives (Clark et al., 2016). In the present article, the idea that the COVID-19 pandemic has “helped“ the flipped classroom in terms of student acceptance as a teaching and learning method is put forward. When COVID-19 ultimately impacted higher education in the U.S. in March 2020, colleges and universities switched from on-campus to remote instruction to ensure safety and social distancing. Students subsequently received synchronous and/or asynchronous instruction remotely through online technologies such as web conferencing software and pre-recorded videos. Thus, both students and instructors were challenged by a very abrupt, unprecedented change from typical on-campus delivery of coursework to instruction that had to be conducted in a dispersed manner in non-traditional settings. These dispersed, non-traditional settings involved the potential for distractions, lessened student motivation, and lack of social connection.

In addition to presenting its own data, the present article also discusses evidence from the recent existing literature that suggests the remote online environment may be beneficial for the advancement of the flipped classroom. Based on recent meta-analyses and literature reviews presented in the next section, the flipped classroom is a promising approach in the future of higher education.

With the flipped classroom, students are expected to begin learning foundational content independently before class. During class, they subsequently engage in practice with and application of the content. Independent learning occurs “at home“ via pre-recorded videos, automated quizzes, and/or textbook readings. Unfortunately, the independent learning aspect of the flipped classroom has been associated with drawbacks, as identified by students, including distractions while watching videos at home, difficulty learning from a video, perceptions of having to “teach oneself,” and insufficient motivation to watch videos (Clark et al., 2018). To enhance the independent learning aspect of the flipped classroom via greater personalization, individualization, and feedback for students, the authors have undertaken a multi-school, collaborative NSF study on the use of adaptive software in a flipped undergraduate numerical methods course. This follows an exploratory study at one of the schools where adaptive lessons were created for half of the course topics (Clark & Kaw, 2020). Adaptive software includes electronic resources such as videos, text, quizzes, and simulations that aim to personalize the learning path (Clark & Kaw, 2020).

With the greatly increased need to manage classroom interactions and activity electronically in the COVID remote environment, student comfort with as well as acceptance of learning with electronic resources may have taken an unanticipated upward turn. Thus, the pandemic may have had a positive impact on the flipped classroom in terms of student perspectives. In the present article, flipped instruction from 2020-2021 in an undergraduate engineering numerical methods course at three universities in the online environment of COVID was compared to onsite (i.e., on-campus, pre-COVID) flipped instruction at these schools to explore potential differences. An extensive study of the flipped classroom had previously been undertaken by the authors at these three universities as part of prior NSF-funded research between 2013 and 2016 (Clark et al., 2018). This previous research by the authors with numerical methods coursework most directly links to and enabled the present comparative study (Clark et al., 2018). With the previous research, blended and flipped instruction were compared at the three universities, and students identified demanding expectations with flipped instruction but pointed to benefits as well, including better preparation compared to blended instruction (Clark et al., 2018). Results gathered thus far in the remote setting-point towards a positive impact of the online environment on the flipped classroom, including the decreased perception of the "load" imposed by the flipped classroom and the "effort" required. Other desirable results remained unchanged upon the move to remote instruction, which was also a good outcome for flipped instruction. These and other findings from conducting a flipped STEM course in an online environment at three universities are presented, including classroom environment perceptions, student requests for enhanced support and incentives, benefits identified, motivation levels, and perceived learning. The following research questions guided this article:

1) What impact has remote online instruction had on the classroom environment in a flipped engineering course?

2) What impact has remote online instruction had on student perceptions of the benefits and drawbacks of a flipped engineering course?

2. Literature Review

2.1 Flipped Classroom Research

Over the past three years, several meta-analyses and systematic literature reviews have been published on student perceptions and achievement in the flipped classroom. These have been conducted in engineering and the health professions as well as across educational disciplines. They have shown the flipped classroom as preferable to the lecture-based classroom. For example, a 2019 meta-analysis involving 29 studies in engineering education in both K-12 and higher-education contexts concluded that the flipped classroom promoted student achievement relative to the traditional classroom, based on an average Hedge's *g* effect size of 0.29, with qualitative evidence that self-paced learning before class and increased problem-solving during class were the predominant reasons (Lo & Hew, 2019). Similar increases in performance and affective outcomes for engineering students were reported in a recent meta-study (Birgili et al., 2021). Another systematic review and synthesis of research on the flipped classroom in engineering higher education concluded that students in the flipped classroom learned the course content as well, if not better, than students in the traditional classroom, based on 25 studies reporting mean test results (Karabulut-Ilgu et al., 2018). This review highlighted the following as benefits of the flipped classroom: flexibility (i.e., 24/7 access to materials, video pause/rewind/re-watch), enhanced interaction with peers and instructors, professional skills development, and student engagement (i.e., better class preparation) (Karabulut-Ilgu et al., 2018). On the reverse side, the following challenges were highlighted: instructor workload (i.e., front-end investment, assisting many students at once during class) and student difficulties (i.e., technical issues, uninteresting materials, resistance) (Karabulut-Ilgu et al., 2018). Finally, this review concluded a scarcity of qualitative research needed for an in-depth understanding of the flipped classroom (Karabulut-Ilgu et al., 2018). The present research includes a qualitative component with instructor interviews and open-ended survey responses, which were analyzed in a structured manner.

In a study of gender issues in undergraduate engineering, the flipped classroom may have been more suited to females, as they performed significantly better than their male classmates on the final grade (Chiquito et al., 2019). This higher suitability to females was not the case in the traditional classroom (Chiquito et al., 2019). On exams, females in the flipped section performed better than females in the traditional section, although not significantly so. The opposite was true for males, who performed better on exams in the traditional versus flipped section, although not significantly so (Chiquito et al., 2019).

Systematic reviews and meta-analyses across multiple educational disciplines have also been conducted. A review involving 71 research articles, with 80% involving higher-education and 16% involving K-12 students, found that the most frequently reported benefit of the flipped classroom was improved learning performance, with 52% of the articles citing this advantage qualitatively (Akçayır & Akçayır, 2018). Relative to challenges, the majority related to outside-of-class activities, including inadequate student preparation and the need for assistance and guidance at home (Akçayır & Akçayır, 2018). Another multidisciplinary, K-12 through higher-education meta-analysis based on 55 publications concluded an overall positive effect of the flipped classroom (relative to the traditional classroom) on student cognitive learning outcomes, with an effect size of $g = 0.19$, which was significantly different from zero (Cheng et al., 2019).

Another multidisciplinary structured review involving 31 studies drew an interesting conclusion about the state of flipped classroom research as relatively “local,” “scattered,” or “siloed,” meaning that it mainly consisted of small-scale, local case studies (Lundin et al., 2018). These constraints imply that few of these studies can make generalizable claims; therefore, future research should aim to make connections with prior research (Lundin et al., 2018). The present research has an explicit connection to undergraduate flipped classroom research conducted with previous NSF funding at our three schools (Clark et al., 2018). Lundin’s review also found flipped classroom studies to be focused on higher education in the U.S. within STEM areas (Lundin et al., 2018).

Education in the health care professions has also embraced the flipped classroom, which has gained in popularity. A meta-analysis that included 28 studies found an effect size of 0.33 (which was significantly different from zero) in favor of flipped over traditional classrooms (Hew & Lo, 2018). Also determined was the effectiveness of quizzes given at the start of class to assess and motivate learning of the pre-class material (Hew & Lo, 2018). This review also concluded student preference for the flipped versus traditional classroom, with 71% of student respondents across five studies preferring flipped to traditional instruction (Hew & Lo, 2018). A final conclusion was the need for longer-term, longitudinal follow-up studies to assess learning with the flipped classroom (Hew & Lo, 2018).

A second meta-analysis that focused on the health-professions in higher education found effect sizes that were significantly different from zero in favor of the flipped versus traditional lecture-based classroom with respect to the outcomes of exam scores, pre-to-post exam score change, and course grade (Chen et al., 2018). For all 46 studies combined, the effect sizes ranged from 0.35 to 0.47 (depending on the particular outcome), and for the 32 health-sciences studies, the effect sizes ranged from 0.44 to 0.60 (Chen et al., 2018).

Finally, in a review of the flipped classroom in undergraduate medical education that included 26 articles, medical students generally had high degrees of satisfaction with readily accessible pre-class videos and active and interactive learning during class, which increased their motivation and engagement (Ramnanan & Pound, 2017). This review also indicated that students generally perceived improved learning and knowledge with the flipped classroom, although performance assessment data has provided only limited evidence supporting this (Ramnanan & Pound, 2017). Students perceived their lifelong, self-directed learning skills to be developed or enhanced by the flipped classroom (Ramnanan & Pound, 2017).

2.2 The Flipped Classroom and COVID-19

The COVID-19 pandemic drove the quick "adoption" of flipped instruction in some cases. For example, a quick redesign of a traditional in-person course in Dynamic Systems & Controls to an online format was accomplished using the flipped classroom, and this format was well-received by the senior-level undergraduate students (Reck, 2020). The end-of-term evaluations indicated strong student agreement to the overall effectiveness of the teaching technique and an environment conducive to learning (Reck, 2020). Other areas of engineering education responded similarly, including biomedical engineering. In an introductory bioengineering course for undergraduates, the flipped classroom was rapidly adopted to engage students with lecture content, create a sense of community, and facilitate peer-to-peer interaction and group work (Fogg & Maki, 2021). To this end, the authors stated that students engaged well with the course and performed well, with the majority of students watching all the videos despite also having written handouts available to them (Fogg & Maki, 2021). Although group work was still challenging, the authors stated that many elements of the course would be maintained for the future (Fogg & Maki, 2021).

Outcomes of the use of the flipped classroom during COVID in other engineering or STEM courses have continued to emerge. In a university materials engineering course, outcomes were compared between two portions of the same semester when the pandemic struck (Santos, 2021). During the first portion of the semester, in-person traditional instruction was used, and for the latter portion, online flipped instruction was applied. The authors concluded students benefitted from the change to a flipped classroom, as many students with low scores under traditional instruction obtained very good scores with the flipped classroom (Santos, 2021). In addition, the mean test score was higher with flipped vs. traditional instruction, as was student satisfaction related to learning activities (Santos, 2021). In a college-level chemical engineering course, the flipped classroom in the remote setting was well received based on student written comments, including "worked well with the online aspect." (Lai, 2021). However, the author suggested further investigation of practices for supporting online student group work and collaboration, such as with breakout rooms (Lai, 2021). In a similar fashion, struggles with online group work were encountered in a sophomore-level engineering Statics course in the fall 2020, when the author decided to switch from traditional to flipped instruction mid-semester due to underperformance of these undergraduates (Griesemer, 2021). However, in the flipped version of the course, students reported improved grades, better understanding, and increased engagement (Griesemer, 2021). Finally, in an undergraduate Biochemical engineering course, more than 95% of survey respondents accepted the idea of an online flipped classroom as a replacement for traditional instruction during COVID-19 (Azmin et al., 2021).

Additional articles have emerged globally with positive reviews of or recommendations for the flipped classroom during the COVID-19 pandemic. At a technical university in China, the flipped classroom improved engineering student learning, attention, and concentration in the online environment (Tang et al., 2020). In an article in an Asian educational journal, the flipped classroom was recommended for online university education in the wake of COVID-19, including the use of instructor incentives for using it (Yen, 2020). The flipped classroom was advocated for developing countries during COVID-19 since pre-recorded videos relieve some of the internet burden imposed by synchronous platforms (Singh & Arya, 2020). A summary of flipped classroom experiences during the lockdown period at one Peruvian and two Spanish universities led to the conclusion that pre-recorded videos are here to stay, given the positive impact on teaching practices in engineering and construction courses (Mosquera Feijóo et al., 2021).

In fact, the pandemic may have "helped" the flipped classroom in terms of popularity and use. At another Spanish university, there was a significant increase during the lockdown in the frequency of flipped classroom sessions and the number and variety of video and audio files, based on a faculty questionnaire (Collado-Valero et al., 2021). This article stated that the "flipped classroom is boosted by the circumstances." (Collado-Valero et al., 2021, pp. 10).

Medical programs proposed the application of the flipped classroom during COVID-19 to maintain rigorous educational practices, including for surgical residency programs (Chick et al., 2020). Medical professionals have advocated that the online infrastructure, videos, sunk costs, and curricular flexibility initiated by the pandemic should be leveraged to "modernize" medical education by pushing for an eventual rollout of the flipped classroom on a broader scale (Chen & Mullen, 2020).

Several studies that compare online to onsite flipped instruction (such as the present study) have emerged and suggest that the online environment is (at a minimum) not associated with a decline in educational outcomes in the flipped classroom. A university in Hong Kong found that students enrolled in an online flipped course during the pandemic performed equivalently to students who had taken the course before the pandemic (Jia et al., 2021). In addition, student engagement remained consistently high during the online flipped course (Jia et al., 2021). At a Spanish university, although it was found that "collaboration with and learning from classmates" was supported to a significantly lesser degree in the online versus onsite flipped classroom, no other significant differences were found in students' assessment of their 21st century skill development in the online vs. onsite environment (Latorre-Cosculluela et al., 2021).

3. Methods

3.1 Classroom Implementation

At each of the three schools in this study, flipped instruction in an undergraduate engineering numerical methods course was employed in the online environment during the fall 2020 and spring 2021 semesters in response to the COVID-19 pandemic. This online flipped modality was implemented at the University of South Florida (USF) and Arizona State University (ASU) in the fall of 2020 and Alabama A&M University (AAMU) in spring of 2021. Previous to this, an extensive study of the flipped classroom had been conducted at these three schools as part of NSF-funded research (Clark et al., 2018). The onsite, on-campus flipped classroom was studied at USF during fall 2014 and fall 2015, at ASU during fall 2015, and at AAMU during spring 2016. We were, therefore, in a unique position to directly compare the flipped classroom at three engineering schools in the online (i.e., due to COVID-19) versus pre-COVID onsite environment. The numerical methods course at each school covered the same topics, including differentiation, nonlinear equations, simultaneous linear equations, interpolation, regression, integration, and ordinary differential equations.

The participants consisted of undergraduate students (i.e., primarily junior and senior-level) from mechanical engineering (USF), civil/ environmental engineering (ASU), and electrical/computer engineering (AAMU). The numbers of participants for whom we had both demographic and final exam data were as follows in the onsite version of the course: 88 USF, 69 ASU, and 23 AAMU students. In the online version, these participants were as follows: 86 USF, 51 ASU, and 22 AAMU students. Students from multiple engineering disciplines and university types increase the generalizability of our results. USF and ASU are public research universities. and AAMU is a public historically black college/university.

For the pre-COVID onsite delivery of the flipped classroom at these schools, the in-class learning consisted of clicker questions, micro-lectures based on student needs, and active group work with the instructor circulating among students to assist. Before the class session at each school, students watched video lectures or accessed the textbook to prepare for class, completed a quiz, and responded to an essay question on the most difficult or interesting topic from their preparation. After class, students also completed a quiz and worked on problem sets and programming projects outside of class. Additional implementation details can be found in a previous publication (Clark et al., 2018).

With the online version of the flipped course, which was precipitated by COVID restrictions at each school, the pre and post-class activities remained similar to those in the onsite environment. However, the in-class activity differed somewhat in the online vs. onsite environment. The goal in the online environment was to replicate the onsite active learning experience as much as possible. To this end, the following were used at USF in the remote environment: synchronous class sessions via Blackboard Collaborate Ultra (BBCU), breakout rooms for group problem solving, clicker questions via Microsoft Forms, and mini-lectures in response to student needs and difficulties. The breakout rooms were formed randomly, with approximately four students per room. The instructor and teaching assistant(s) visited the breakout rooms to monitor and assist. At the end of the group time, everybody returned to the main room for a discussion of the problem solutions. A summary of the use of class time at each school in the online flipped classroom is given in Table 1.

Similarly, at ASU, each synchronous class session (via Zoom) began with an interactive lecture and consisted of interspersed practice time. Students used the chat window to respond to questions during the lecture. The lecture was adjusted for student needs, including mini lectures as needed. In the latter portion of the class, students completed homework in randomly assigned breakout rooms for active group learning. A personal response system (i.e., Piazza polling) was used during class.

At AAMU, where the class size was much smaller, synchronous class sessions were held using Blackboard Collaborate Ultra (BBCU). Breakout rooms were not used, given the small class size. An online discussion board in Blackboard was used to promote student interaction. At all three schools, proctoring software was used, specifically either Proctorio (https://proctorio.com) or Respondus Monitor (https://web.respondus.com/he/monitor). At USF and AAMU, the final exam was open-notes, and at ASU, it was closed-book, closed notes with a "cheat sheet" permitted.

3.2 Final Exam and Demographic Survey

A final exam at each school consisted of free-response questions, which were designed to assess the higher-level skills of Bloom's taxonomy (Wiggins & McTighe, 2005). Before the switch to remote instruction, the free-response questions had differed across the schools anyway due to the different engineering majors. However, they had remained the same at each school across semesters of the previous flipped classroom research. But, to maintain the academic integrity of the original free-response questions for future research and given the open-book, open-notes nature of the exams at USF and AAMU, the free-response questions had to be altered for the online environment. Unfortunately, this did not allow an exact comparison of the free-response questions at each school in the onsite vs. online environment (Kaw, 2021).

At each school, four free-response questions were posed, each graded on a 0-4 scale. The instructor remained the same in the online versus onsite environment at each school, and each instructor used the same rubric to guide the assessment of the responses on the 0-4 scale. Unfortunately, a last-minute university-wide calendar change at ASU due to the pandemic precluded administration of these free-response questions there. Given these realities, the free-response results were not statistically compared in the onsite versus online environment using hypothesis testing or effect sizes. The adjusted averages were calculated and are displayed in the results with no statistical comparisons of onsite vs. online outcomes. The averages were adjusted based on the student's pre-requisite GPA, which served as a control variable. This adjustment was done using the analysis of covariance (ANCOVA) procedure in SPSS to take prior academic performance into account (Norusis, 2005).

The pre-requisite GPA and other demographic variables were collected via a demographics survey. Students entered a self-selected code to the survey, which was then matched to the code provided on the exam to enable GPA-adjusted exam averages. The pre-requisite GPA was calculated using grades earned in pre-requisite courses, such as Calculus, ordinary differential equations, and programming concepts. Other demographic data collected included gender, race/ethnicity, Pell grant status, and transfer status (e.g., from a community college). These demographic variables were collected to enable a stratified analysis of the exam results. Permission was granted by each school's research protection's office to conduct this study.

3.3 Surveys: Classroom Environment and Flipped Classroom Evaluation

Students were asked to complete a classroom environment inventory and an evaluation survey of the flipped classroom experience at the end of the semester. Both were administered in an anonymous fashion, with no student codes collected. This procedure was followed in both the onsite and online environments at all three schools, enabling a direct comparison of student affect and perspectives in both environments.

The classroom environment was assessed using the College and University Classroom Environment Inventory (CUCEI) (Fraser & Treagust, 1986). This validated instrument measures seven psychosocial dimensions of the classroom, such as cohesiveness (i.e., students know and help one another), involvement (active student participation in class activities), and personalization (i.e., interaction with the instructor & concern for student welfare). The dimensions of the CUCEI align with the goals of the flipped classroom, and our previous flipped classroom research employed the CUCEI. There are seven questions per dimension (each on a 1 to 5 scale), with 5 being the most desirable. The CUCEI data were analyzed for each school using a MANOVA, or multivariate analysis of variance, given the seven outcome variables (i.e., dimensions) across the two environments (i.e., onsite vs. online) (Field, 2005; Norusis, 2005). With the testing of seven dimensions, each univariate p-value (i.e., one for each CUCEI dimension) was adjusted using the Bonferroni correction (Perneger, 1998). In this case, each univariate *p*-value was multiplied by seven to determine an adjusted *p*-value, which was then compared to $\alpha = 0.05$. Given the smaller sample sizes for AAMU, the MANOVA univariate *p*-values were corroborated by results from the non-parametric Mann-Whitney test (Norusis, 2005).

To assess practical significance, effect sizes were calculated using Cohen's *d* (Sullivan & Feinn, 2012; Kotrlik et al., 2011). The onsite implementation of the flipped classroom was considered the reference category for this analysis. A 95% confidence interval for each *d* was also calculated (Cumming & Finch, 2001). Although our effect sizes tended to be in the small to medium-size range based on traditional rule-of-thumb ranges, they are in line with effect sizes found in meta-analyses of the flipped vs. traditional classroom discussed in the literature review. For the online environment, one question from the 49-item CUCEI was removed because it was not applicable (i.e., it pertained to classroom seating). A median substitution was done for this item using the median value of the item for the onsite implementation at each school.

The flipped classroom evaluation survey consisted of a mixture of closed and open-ended questions to assess student perspectives of their motivation, effort, required responsibility, and preferences with flipped instruction as well as perceived benefits and drawbacks. The open-ended responses on benefits and drawbacks were analyzed in a structured manner by two analysts via a content analysis (Neuendorf, 2002). Using an established coding scheme developed as part of the previous flipped classroom research, each analyst coded the responses independently (Clark et al., 2018). The analysts subsequently discussed the codes assigned and determined the final consensus codes to assign. The content analysis was assessed for inter-rater reliability using Cohen's Kappa, for which values above 0.75 would indicate strong agreement beyond chance (Norusis, 2005). The following Kappa values were achieved for the analysis: $\kappa = 0.76$ for the benefits responses and $\kappa = 0.70$ for the drawbacks/suggestions, suggesting strong and good agreement beyond chance, respectively. Occurrence percentages for the various codes were compared statistically using the z-test of proportions (Walpole, et al., 2012).

4. Results

4.1 Classroom Environment Inventory

The results from the classroom environment inventory (CUCEI) are presented next by school. The response rate for the CUCEI across the three universities and multiple years of the present study was 82% of students enrolled in the course.

At USF, the mean for the **cohesiveness** dimension was significantly lower for the flipped classroom in the online versus onsite (i.e., on-campus) environment, with mean scores of 2.15 and 2.77, respectively. These two means were significantly different from one another, with $p < 0.0035$ after Bonferroni's adjustment for multiple comparisons, as shown in Table 2. The effect size was $d = -0.79$. This result is not unexpected, as the remote online environment forced physical separation among students, which made getting to know and working with others more difficult. In a post-semester interview, the instructor recalled that only two-thirds of the breakout rooms contained a group that was reasonably engaged in the assigned task, while the other one-third of the groups were not working. Upon dropping into this latter set of rooms, there was typically no response from students. This observation aligns with the lower cohesiveness score in the flipped online environment. The instructor estimated that after the first month of the semester, only two-thirds of enrolled students joined the class sessions synchronously, which would also decrease the opportunities for students to work together during class.

At USF, student **satisfaction**, which is focused on the enjoyment of classes, was also lower in the online environment, although not significantly so and with an effect size of $d = -0.11$. In general, the instructor perceived less student satisfaction (i.e., enjoyment of classes) in the online vs. onsite environment, in particular, because the face-to-face component was absent.

During the class sessions at USF with mini-lectures, students were asked to respond to questions via the chat window. However, the instructor recalled only a few higher-performing students interacting via the chat window. In general, the instructor perceived that interactivity during class time in fall 2020 was much less than previously with onsite flipped instruction, including fewer questions in class by students. Also, when the USF instructor visited the various breakout rooms, he did not have a high level of "visibility" into students' work, especially in comparison to when he could physically circulate in the classroom and monitor students. At other times upon dropping into breakout rooms, the instructional team felt a sense of being intrusive to students. Therefore, students were eventually asked to "raise their hands" for the instructor or a TA to provide assistance.

Interestingly, the students did not perceive significantly-decreased instructor interaction or concern nor decreased participation on their parts in the online classroom based on the **personalization** and **involvement** scores, respectively. Although in-class questions were fewer in the online environment, the Canvas discussion boards contained more questions than were asked during class in the instructor's assessment.

To exhibit a caring attitude toward his students, the USF instructor asked students to write personal introductions (e.g., hometown, hobbies, goals, etc.) using the Canvas discussion board during the first week of class. The instructor subsequently responded to each introduction (approximately 100) with a one-to-two minute audio response, which he believed students appreciated. He also told students to approach him with any exceptional circumstances (e.g., health concerns), which he would consider on an individual basis relative to extensions and make-up exams. Interestingly, there was an increase in the **individualization** dimension in the online environment, from 2.43 to 2.54.

Another dimension with a higher average in the online vs. onsite flipped environment at USF was **task orientation**, or organization and clarity of class activities (4.03 vs. 3.84, respectively), with an effect size of 0.29. The instructor's Canvas website was highly organized and perhaps more so than in the past. It was also highly accessible, including by students with disabilities, all due partly to formal training he had received from the teaching and learning center at his university. Office hours were available to students every day during the semester and were covered by the instructor and two TAs.

The pattern was similar at ASU for the **cohesiveness** dimension, with a significantly-lower mean score in the online versus onsite environment (i.e., 2.27 vs. 3.13, respectively). The effect size was $d = -1.15$, as shown in Table 3. Similar to the USF instructor, the ASU instructor estimated that only 50-60% of the breakout rooms contained an actively working team. Interestingly, the **satisfaction** dimension was significantly higher in the online versus onsite environment at ASU, with satisfaction means of 3.31 versus 2.86, respectively, and an effect size of $d = 0.51$. This difference was significant after the Bonferroni adjustment (adjusted $p = 0.035$).

The ASU instructor was pleased with use of the chat window during the interactive lecture, with an estimated one-third to one-half of students using it to respond to questions. Interestingly, at both USF and ASU, the **involvement** means were approximately the same in the online and onsite environments, with effect sizes at both schools of d = -0.03. The involvement dimension assesses active student participation in class activities. Thus, students at both schools perceived approximately the same activity level in the classroom in the online vs. onsite flipped environment.

However, the ASU instructor reflected in a post-semester interview that from an overall perspective, student interactivity with her during fall of 2020 was less compared to onsite flipped instruction. Recall that the USF instructor had reached the same conclusion. The ASU instructor believed that not being able to physically interact with students before or after class or during problem-solving contributed to the lessened interactivity since relatability to the instructor and a sense of personal touch were missing for the students. Despite this, the **personalization** mean scores at ASU were approximately equal in both environments. The ASU instructor also mentioned that she too did not have "visibility" into group problem-solving.

At AAMU, the **cohesiveness** dimension likewise had a significantly lower mean score in the online versus onsite environment (i.e., 3.17 vs. 3.79, respectively). Recall that this was the case for USF and ASU as well. The effect size was d = -0.85, as shown in Table 4, which was similar to the effect size of -0.79 at USF for the cohesiveness dimension. The AAMU instructor noted the decreased opportunity for peer interaction in the remote environment on programming projects and minimal participation with the discussion board. The **satisfaction** dimension was higher in the online environment at AAMU (as it was at ASU), although not significantly so. The AAMU instructor felt students had somewhat positive (i.e., mixed) feelings about remote, online instruction since it offers convenience but at the expense of in-person interaction. The **involvement** means were similar in the online and onsite environments, with an effect size of d =

-0.09. This was the same outcome seen for USF and ASU, suggesting that students across schools perceived the same level of participation during class in the online vs. onsite classroom.

For AAMU, the univariate *p*-values in Table 4 were corroborated by a Mann Whitney test for each dimension (given the smaller sample size of n=22 in each group). In fact, the *p*-value for the Mann-Whitney test for the cohesiveness dimension was 0.004, in line with the MANOVA univariate *p*-value of 0.007. The Mann-Whitney *p*-values for the other CUCEI dimensions were similarly non-significant. Upon applying the Bonferroni adjustment, the univariate *p*-value for cohesiveness was significant ($p = 0.049$).

4.2 Flipped Classroom Evaluation Survey

A combination of open and closed-ended results from the flipped-classroom evaluation survey are presented in the subsections below. Results from the two open-ended questions on perceived benefits and drawbacks/suggestions are presented first, followed by results from a selection of the closed-ended questions. The response rate for the evaluation survey across the three schools and multiple years of the present study was 80% of enrolled students.

4.2.1 Benefits (Open-Ended Responses)

For the perceived benefits, the largest change was the increase in the percentage of responses for the "Video/Online Learning" category, which is highlighted in Table 5. This category pertains to re-watching videos and recordings and the associated flexibility and convenience, including working at one's own pace. The percentage of responses increased from 13% to 39% in going from onsite to online instruction. This increase was for the three schools combined, with USF and ASU associated with larger increases and AAMU having a smaller increase. These two proportions (13% vs. 39%) were significantly different based on a z-test of proportions ($p \approx 0.000$). To interpret this finding, since more content is recorded in the remote online environment (e.g., Zoom recordings, videos, etc.), recorded content may have been forefront in students' minds when responding to this open-ended question. Many students enjoy the flexibility and helpfulness of recorded material. Thus, this benefit may have occurred to students first when asked about benefits. New expectations may likely exist in higher education for recorded content after the remote instructional period ends (Mosquera Feijóo et al., 2021). On the flip side, there may be increased acceptance going forward of teaching and learning with recorded material. During the pandemic, it became mainstream to "learn on one's own" with recorded content. This contrasts with existing views by some students that the flipped classroom is a method by which the instructor does not have to teach students (Jarvis, 2020).

In Table 5, the small decrease in "Enhanced Learning or Learning Process" (i.e., 41% to. 35% in the onsite to online environment) was not significantly different from zero based on a z-test of proportions. Thus, these two proportions were statistically equivalent ($p \approx 0.23$). This was also the case for the "Preparation, Engagement, & Professional Behaviors" category ($p \approx 0.067$). Thus, the positive outcomes of learning and learning processes, engagement, and professional behaviors were not perceived by students as significantly reduced in the online versus onsite environment. These were good results for the flipped classroom in the online environment.

When analyzing the perceived benefits in the online environment, a student misunderstanding was uncovered related to the nature of the flipped classroom. Multiple students believed a lack of in-person instruction characterized the flipped classroom. However, the lack of in-person instruction and face-to-face class time was a result of the pandemic and not the flipped classroom itself. A lesson learned was the need to explicitly discuss the defining elements of the flipped classroom upfront with students and how it is being operationalized in the remote environment.

4.2.2 Drawbacks and Suggestions (Open-Ended Responses)

The most notable change in perceived drawbacks and suggestions in moving from the onsite to the online environment was the large increase in the "Prepare, Equip, & Incentivize Students" category, as shown in Table 6. The total proportion of responses increased from 9% to 28%, and these two proportions were significantly different ($p \approx 0.000$). There was actually an increase in this category at each school. Thus, students requested significantly more support and resources in the flipped classroom in the online environment, which may have been related to motivational challenges they were experiencing in the remote environment. Example requests included the following:

- One small change I would make is to swap the due times so that the pre-class homework is due before the muddiest point.
- Perhaps having more (optional) canvas quiz questions? Or optional problems that are automatically graded in a separate quiz?
- To ensure students have motivations for videos make them sort of like assignments.
- I think for improving the muddiest point discussion board, it could include a self-reflection component where we would have before the next class to go back and reply to ourselves and try to answer our own questions based on what we learned afterward (like in the lecture, slides, doing examples, etc.).
- Give students the option to work slightly ahead.

Another notable change was the perceived decrease in "Load, Burden, or Stressors" from the onsite (40%) to the online (24%) flipped classroom, with a decrease at each school. These two proportions were significantly different ($p = 0.004$). Thus, the flipped classroom was perceived as significantly less of a burden, load, or stressor in the online vs. onsite environment, which was another good outcome for the flipped classroom. This may have been the result of greatly increased learning via videos and recordings in general with remote instruction, positioning it as more mainstream in higher education. Very interestingly, there was a significant decrease in the proportion of responses indicating "decreased learning" in moving from the onsite to the online environment, from 11% to 5% (p = 0.045). Thus, students had a significantly better perception of their learning in the online environment by virtue of a smaller proportion who felt their learning was lessened or decreased in the flipped classroom.

4.2.3 Closed-Ended Responses

Results related to student preferences for the flipped classroom, effort, responsibility, and motivation are presented next, with a direct comparison of the onsite vs. online environment.

4.2.3.1 Preference for Flipped Classroom. Survey Question: *Do you prefer a flipped classroom over the usual method of instruction?* The following results for this question were obtained for each school in both the onsite and online environments. With the combined data, there was an increase in the proportion who preferred the flipped classroom from 26% to 30%, as shown in Table 7. However, these two proportions were not significantly different based on a z-test of proportions (p = 0.45).

4.2.3.2 Effort Required. Survey Question: *How would you rate the overall effort required of you in this class compared to other college/university engineering classes (either flipped or non-flipped)?* Overall, there was a reduction in the perception that *more or much more* effort was required in the flipped classroom in the online environment, falling from 71% to 58%, by combining the scale categories in Table 8. These proportions were significantly different (p = 0.015), yet another good outcome for the flipped classroom.

4.2.3.3 Responsibility Required. Survey Question: *With the flipped classroom, how would you rate the responsibility placed on you compared to the usual method of instruction?* There was also a reduction in the perception that *more or much more* responsibility was required in the flipped classroom in the online environment, falling from 80% to 73%, by combining these scale categories in Table 9. These proportions were not significantly different ($p = 0.14$), however.

4.2.3.4 Motivation. Survey Question: *With the flipped classroom, I had the motivation to engage in the necessary learning outside the classroom.* There was less agreement to this question in the online vs. onsite environment, falling from 43% (onsite) to 32% (online), upon combining "agree" and "strongly agree" across schools in Table 10. These proportions (43% vs. 32%) were significantly different ($p = 0.038$). However, academic motivation in higher education has declined with remote instruction more generally (Browning et al., 2021).

4.3 Free-Response Exam Results

At USF, all groups had higher adjusted free-response scores in the online environment (Table 11). Recall that averages were adjusted based on the pre-requisite GPA so as to take the student's general academic performance into account. In the instructor's interpretation, the open-notes nature of the final exam in the online environment may have contributed to this result. In the onsite environment, the final exam was a closed-book, closed-notes exam. Although he adjusted (i.e., increased the challenge level of) the free-response questions for the open notes to the extent he considered fair, there was no precedent for him to follow. Likewise, the AAMU instructor also adjusted the free-response questions for the remote environment, but with the opposite effect occurring. This highlights the challenges of creating "equivalent" exams for direct comparison purposes.

5. Summary

Flipped instruction in an undergraduate numerical methods course during the COVID pandemic was conducted and compared to onsite (i.e., on-campus) flipped instruction in terms of student perceptions. This study was done at three universities, where previous extensive research with the flipped classroom occurred between 2013 and 2016. Results gathered in the online environment suggest positive changes in student perceptions of flipped instruction compared to the onsite, on-campus environment. These included a significantly decreased perception that the flipped-classroom imposed load or burden on students, as evidenced by decreased proportions of students who discussed burden and stress. There was also a significant decrease in the proportion of those perceiving "lessened" learning in the flipped classroom. In other cases, desirable outcomes were not lessened in moving to the remote environment. These desirable outcomes included learning and learning processes, engagement, and professional behaviors.

Additional important findings associated with the remote environment were uncovered. With the classroom environment as measured by the seven-dimension College and University Classroom Environment Inventory (CUCEI), the mean for the cohesiveness dimension was significantly lower for the flipped classroom in the online versus onsite environment at each of the three schools, with effect sizes $|d| \geq 0.79$. Since cohesiveness is driven by students knowing and helping one another, this outcome is not surprising and must be kept in mind by educators about the remote environment. Interestingly, at all three schools, the involvement dimension means were approximately the same in the online and onsite environments, with effect sizes $|d| \leq 0.09$. Since this dimension assesses active participation in class activities, students generally perceived approximately the same level of activity in the classroom in the online vs. onsite environment, suggesting that this aspect of the flipped classroom is reproducible in the remote environment.

Unfortunately, student motivation for independent learning in the flipped classroom was significantly less in the online environment. This reduction in motivation was also not surprising, as it aligns with general declines in motivation in higher education in the remote setting (Browning et al., 2021). An interesting finding was the significant increase in the proportion of students who requested additional resources, support, and incentives in the remote flipped classroom. This result may be related to the students' struggles with motivation.

5.1 Limitations

One of the main limitations of this research was the inability to compare final exam averages between the onsite and remote online environments. This was a result of the need to maintain the academic integrity of the original final exam questions for future research as well as the availability of resources during online examinations. They had to be altered for the online environment, not enabling an exact comparison at each school in the onsite vs. online environment. In addition, the free-response questions could not be administered at ASU because of a last-minute, university-wide calendar change.

In addition, our study was quasi-experimental since students could not be randomly assigned to the various classrooms. The sample sizes for one of the schools were small, reducing power and robustness in the classroom environment analysis. However, the results were corroborated using a conservative statistical procedure (i.e., non-parametric Mann-Whitney test) and effect sizes to enhance the robustness of the conclusions.

6. Conclusions

The recent emerging literature has suggested that the remote, online environment as dictated by the pandemic may be beneficial for flipped teaching and learning moving forward. Various empirical results in the present study also suggest this, such as a decreased frequency of stressful and burdensome perceptions of the flipped classroom. Other results suggest equivalent positive outcomes, such as perceived learning and learning processes and professional behaviors. The remote environment possibly may have advanced the popularity and student views of the flipped classroom, and this should be leveraged by instructors and universities. Equivalency may also exist for some outcomes, as shown by several positive outcomes that did not decline in the remote flipped classroom.

However, remote instruction in higher education, as precipitated by the COVID pandemic, has been associated with reports of highly-reduced academic motivation as well as compromised group work and collaboration (Browning et al., 2021; Lai, 2021; Griesemer, 2021). In the present study, issues with group work were encountered in using the breakout rooms, in which students did not always participate as expected. Scores were not assigned to the group work completed (or not completed) during the breakout room sessions, but the instructor would consider doing this going forward to enhance group work. Others have also encountered problems with the use of breakout rooms, including students not talking, cameras turned off, and unpreparedness (McMurtrie, 2020). The remote environment has also forced changes in administering and taking exams, all of which are not necessarily desirable, including for conducting classroom research, as we encountered in this study. Teaching during such uncertain times may lead to dual audiences (i.e., in-person students and remote students). We did not take this approach due to the distractions involved but instead delivered only online sessions.

Therefore, there are potential benefits as well as drawbacks associated with remote, online instruction, as we found in this study. Based on this, we believe the entire range of findings and realities from the COVID-19 period must be understood and considered by instructors and administrators. This will enhance decision-making during continued challenges with COVID or other future crises. Our article adds to the growing body of literature and knowledge on academic-related outcomes during the COVID-19 period. It is most certainly important to document student experiences, achievements, and mindsets during times of crisis and adverse, monumental change, such as the pandemic-induced social distancing that began in March 2020. Comprehensive accounts in the literature are needed to best support students in the event of future crises.

Acknowledgements

This material is based upon work supported partially by the National Science Foundation under Grant Number 2013271, and the Research for Undergraduates Program in the College of Engineering at University of South Florida (USF). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. We wish to thank Nicole Figueroa and Kayla Edwards, undergraduate engineering students who provided invaluable assistance.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Table 1. Online Flipped Classroom.

	Class Time Use			
School	**Synchronous platform**	**Personal Response System or Online Discussion**	**Breakout Rooms for active learning**	**Mini-Lectures for student needs**
USF	√ (BBCU)	√ (MS Forms)	√	√
ASU	√ (Zoom)	√ (Piazza)	√	√
AAMU	√ (BBCU)	√ (BB)		√

Table 2. USF Classroom Environment Comparison: Onsite vs. Online Flip.

Dim	**Mean** (s)		**Univariate *p***	**Univariate *p* (adjusted)**	**Effect Size D**	**95% Confidence Interval for Effect Size**
	Onsite	**Online**				
Coh	2.77 (0.81)	2.15 (0.77)	<0.0005	<0.0035	-0.79	(-1.10, -0.48)
Indiv	2.43 (0.75)	2.54 (0.67)	0.31	1.00	0.16	(-0.14, 0.45)
Inn	2.94 (0.63)	2.71 (0.56)	0.01	0.07	-0.38	(-0.68, -0.08)
Invol	3.18 (0.65)	3.16 (0.52)	0.84	1.00	-0.03	(-0.33, 0.27)
Pers	3.74 (0.83)	3.64 (0.82)	0.41	1.00	-0.13	(-0.43, 0.17)
Satis	3.11 (1.04)	3.01 (0.91)	0.48	1.00	-0.11	(-0.41, 0.19)
Task Or	3.84 (0.69)	4.03 (0.61)	0.06	0.42	0.29	(-0.01, 0.59)
n	89	83				

Coh = Cohesiveness (Students know & help one another)
Indiv = Individualization (Students treated individually/differentially & can make decisions)
Inn = Innovation (Novel class activities or teaching techniques)
Invol = Involvement (Active student participation in class activities)
Pers = Personalization (Interaction w/ instructor & concern for student welfare)
Satis = Satisfaction (Enjoyment of classes)
Task Or = Task orientation (Organization and clarity of class activities)
Note: Flipped onsite was considered the reference category for this analysis.

Table 3. ASU Classroom Environment Comparison: Onsite vs. Online Flip.

Dim	Mean (s)		Univariate *p*	Univariate *p* (adjusted)	Effect Size d	95% Confidence Interval for Effect Size
	Onsite	**Online**				
Coh	3.13 (0.77)	2.27 (0.71)	< 0.0005	<0.0035	-1.15	(-1.52, -0.77)
Indiv	2.61 (0.65)	2.41 (0.70)	.10	0.70	-0.30	(-0.65, 0.05)
Inn	2.89 (0.59)	3.06 (0.53)	.09	0.63	0.30	(-0.05, 0.65)
Invol	3.33 (0.58)	3.32 (0.58)	.88	1.00	-0.03	(-0.38, 0.32)
Pers	4.07 (0.72)	4.06 (0.67)	.92	1.00	-0.02	(-0.37, 0.33)
Satis	2.86 (0.88)	3.31 (0.86)	.005	0.035	0.51	(0.16, 0.87)
Task Or	3.84 (0.58)	4.02 (0.60)	.10	0.70	0.30	(-0.05, 0.65)
n	69	58				

Coh = Cohesiveness (Students know & help one another)
Indiv = Individualization (Students treated individually/differentially & can make decisions)
Inn = Innovation (Novel class activities or teaching techniques)
Invol = Involvement (Active student participation in class activities)
Pers = Personalization (Interaction w/ instructor & concern for student welfare)
Satis = Satisfaction (Enjoyment of classes)
Task Or = Task orientation (Organization and clarity of class activities)
Note: Flipped onsite was considered the reference category for this analysis.

Table 4. AAMU Classroom Environment Comparison: Onsite vs. Online Flip.

Dim	**Mean** (s)		**Univariate *p***	**Univariate *p* (adjusted)**	**Effect Size d**	**95% Confidence Interval for Effect Size**
	Onsite	**Online**				
Coh	3.79 (0.82)	3.17 (0.63)	0.007	0.049	-0.85	(-1.47, -0.23)
Indiv	3.12 (0.54)	3.03 (0.55)	0.56	1.00	-0.18	(-0.77, 0.41)
Inn	3.08 (0.50)	2.99 (0.45)	0.56	1.00	-0.18	(-0.77, 0.42)
Invol	3.47 (0.60)	3.42 (0.51)	0.76	1.00	-0.09	(-0.68, 0.50)
Pers	4.07 (0.56)	3.81 (0.66)	0.17	1.00	-0.42	(-1.02, 0.18)
Satis	3.49 (0.96)	3.69 (0.70)	0.43	1.00	0.24	(-0.36, 0.83)
Task Or	3.96 (0.46)	3.82 (0.52)	0.34	1.00	-0.29	(-0.88, 0.31)
n	22	22				

Coh = Cohesiveness (Students know & help one another)
Indiv = Individualization (Students treated individually/differentially & can make decisions)
Inn = Innovation (Novel class activities or teaching techniques)
Invol = Involvement (Active student participation in class activities)
Pers = Personalization (Interaction w/ instructor & concern for student welfare)
Satis = Satisfaction (Enjoyment of classes)
Task Or = Task orientation (Organization and clarity of class activities)
Note: Flipped onsite was considered the reference category for this analysis.

Table 5. Perceived Benefits of Flipped Instruction (Open-Ended).

Flipped Classroom Benefit	**USF**		**ASU**		**AAMU**		**COMBINED**	
	Onsite	**Online**	**Onsite**	**Online**	**Onsite**	**Online**	**Onsite**	**Online**
Enhanced Learning or Learning Process	41%	34%	45%	43%	32%	16%	41%	35%
Preparation, Engagement & Professional Behavior	36%	20%	30%	24%	37%	42%	34%	24%
No Benefit or Neutral	20%	11%	9%	8%	11%	11%	15%	10%
Alternative Use of Class Time	16%	14%	34%	27%	16%	0%	23%	17%
Video/Online Learning	16%	49%	4%	24%	32%	37%	**13%**	**39%**
Specific to Course or its Videos	5%	5%	4%	6%	5%	5%	5%	6%
Responses	86	76	67	49	19	19	172	144

Table 6. Perceived Drawbacks of and Suggestions for Flipped Instruction (Open-Ended).

	USF		**ASU**		**AAMU**		**COMBINED**	
Flipped Classroom Drawback	**Onsite**	**Online**	**Onsite**	**Online**	**Onsite**	**Online**	**Onsite**	**Online**
Class Time Usage	38%	29%	53%	43%	6%	6%	41%	31%
Load, Burden, or Stressors	37%	31%	50%	20%	17%	6%	**40%**	**24%**
Approach Differently	19%	9%	15%	12%	11%	6%	16%	10%
Learning Decreased	15%	3%	9%	10%	0%	0%	**11%**	**5%**
No Drawbacks or Neutral	9%	6%	3%	4%	0%	29%	6%	8%
Specific to the Course or its Videos	9%	6%	6%	4%	28%	0%	10%	5%
Prepare, Equip, & Incentivize Students	8%	25%	9%	33%	17%	29%	**9%**	**28%**
Inherent to Video Learning	7%	3%	2%	4%	6%	6%	5%	3%
Responses	86	77	66	49	18	17	170	143

Table 7. Preference for Flipped Classroom (Closed-Ended).

Do you prefer a flipped classroom over the usual method of instruction?	**USF**		**ASU**		**AAMU**		**COMBINED**	
	Onsite (n=84)	**Online (n=82)**	**Onsite (n=68)**	**Online (n=57)**	**Onsite (n=23)**	**Online (n=21)**	**Onsite (n=175)**	**Online (n=160)**
Yes	29%	23%	18%	40%	43%	28%	**26%**	**30%**
No	43%	50%	54%	35%	48%	48%	48%	44%
Not Sure Yet	29%	27%	28%	25%	10%	24%	26%	26%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Table 8. Effort Required (Closed-Ended).

How would you rate the overall effort required of you in this class compared to other college/ university engineering classes?	USF		ASU		AAMU		COMBINED	
	Onsite (n=84)	**Online (n=82)**	**Onsite (n=68)**	**Online (n=57)**	**Onsite (n=23)**	**Online (n=21)**	**Onsite (n=175)**	**Online (n=160)**
Much Less	4%	0%	3%	0%	9%	5%	4%	1%
Less	6%	2%	3%	9%	14%	19%	6%	7%
About the Same	16%	34%	23%	35%	18%	38%	20%	35%
More	24%	38%	51%	39%	32%	14%	**39%**	**35%**
Much More	50%	26%	21%	18%	27%	24%	**32%**	**23%**
Total	100%	100%	100%	100%	100%	100%	100%	100%

Table 9. Responsibility Required (Closed-Ended).

With the flipped classroom, how would you rate the responsibility placed on you, compared to the usual method of instruction?	USF		ASU		AAMU		COMBINED	
	Onsite (n=84)	**Online (n=82)**	**Onsite (n=68)**	**Online (n=57)**	**Onsite (n=23)**	**Online (n=21)**	**Onsite (n=175)**	**Online (n=160)**
Much Less	2%	0%	0%	0%	9%	0%	2%	0%
Less	2%	0%	1%	4%	0%	5%	2%	2%
About the Same	14%	22%	18%	18%	17%	57%	16%	25%
More	42%	39%	46%	51%	22%	14%	**41%**	**40%**
Much More	40%	39%	35%	28%	52%	24%	**39%**	**33%**
Total	100%	100%	100%	100%	100%	100%	100%	100%

Table 10. Motivation (Closed-Ended).

With the flipped classroom, I had the motivation to engage in the necessary learning outside of the classroom.	**USF**		**ASU**		**AAMU**		**COMBINED**	
	Onsite (n=84)	**Online (n=82)**	**Onsite (n=68)**	**Online (n=57)**	**Onsite (n=23)**	**Online (n=21)**	**Onsite (n=175)**	**Online (n=160)**
Strongly Disagree	11%	15%	5%	11%	4%	5%	8%	12%
Disagree	26%	22%	26%	33%	17%	29%	25%	27%
Neutral	23%	32%	29%	21%	13%	38%	24%	29%
Agree	34%	27%	34%	33%	48%	29%	**36%**	**29%**
Strongly Agree	6%	5%	5%	2%	17%	0%	**7%**	**3%**
Total	100%	100%	99%	100%	99%	100%	99%	100%

Table 11. Final Exam Free Response Comparison: Onsite vs. Online Flip.

	USF		**AAMU**	
Demog Group	**Adjusted Mean Percentage %** (*s*) n		**Adjusted Mean Percentage %** (*s*) n	
	Onsite	**Online**	**Onsite**	**Online**
All	**40.2** *(19.0)* 88	**54.1** *(19.0)* 86	**57.5** *(25.3)* 23	**51.0** *(25.4)* 22
Female	**44.5** *(19.0)* 15	**57.0** *(19.5)* 10	**75.6** *(34.4)* 5	**43.1** *(34.4)* 5
Male	**39.4** *(19.1)* 73	**53.6** *(19.1)* 76	**54.3** *(24.1)* 18	**51.3** *(24.1)* 17
CC Transfer w/ Associates	**31.9** *(16.2)* 32	**54.2** *(16.4)* 19	**64.1** *(1.8)* 1	**64.0** *(1.4)* 3
URM	**39.0** *(18.2)* 33	**49.2** *(18.2)* 22	**56.7** *(25.7)* 22	**51.4** *(25.7)* 20
Pell	**36.6** *(17.7)* 29	**49.8** *(17.7)* 25	**57.8** *(23.0)* 14	**52.6** *(22.9)* 16