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Flipped Teaching Eased the Transition to Online Learning of College Students in STEM Courses During COVID-19

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Following COVID-19, teaching was abruptly shifted from a live to a virtual format, posing a challenge to both students and faculty. There is a need to employ alternatives, emphasizing targeting the factors that suit Generation Z students for effective learning while maintaining social distancing. Understanding students' perceptions about the educational environment plays a vital role in planning and implementing teaching strategies for the future. Flipped teaching (FT) has been a successful instructional method because it embeds active learning strategies and some remote learning for which students are responsible. This study examined the perceptions of science, technology, engineering, and math (STEM) students (N = 265) while transitioning to online learning in classrooms implementing FT instruction for two cohorts: faculty expanding FT skills and novice FT faculty from a public university and a community college. Findings showed a significant difference between the two groups, with the transitions being more difficult in the courses taught by the novice versus the more experienced faculty ($p < 0.01$). Qualitative data analysis indicated that the FT classrooms eased the transition to fully online learning. The major challenges students faced were the lack of interaction with faculty and peers and a sense of community. In conclusion, FT eased the transition of college students in STEM courses to remote learning during COVID-19.

COVID-19 is the single most unprecedented and devastating global experience people have ever faced in modern history (Bawa, 2020). Most sectors were disrupted, including higher education, which had not faced much disruption for the last few decades. A factor contributing to the disruption is that the higher education community was unprepared. This abrupt shift has compelled institutions to accelerate their transition to online education by applying and modifying existing technical resources and integrating professors and researchers who lack instinctual technological capabilities for online teaching. However, the current COVID-19 pandemic forced colleges to conduct a massive experiment with online education. The pandemic pushed colleges into expanding their educational practice into entirely online asynchronous or synchronous classes on short notice, including lectures and assessments (Quintana, 2020; Rad et al., 2021; Zubașcu, 2020). This was a significant shift because many faculty and students had never experienced online education before. Thus, higher education had to be more flexible and adaptable in deploying resources.

The traditional teaching model typically requires students to passively consume lecture content during class with the expectation of practicing the application of knowledge on their own. This long-established teaching method allows for minimal interaction between the instructor and the students, which can be a major impediment to the current education system. (Thomasian, 2011). Student-centered instruction has been advocated based on research evidence (e.g., Freeman et al., 2014) but is still not widely practiced due to such factors as lack of motivation, low instructor self-efficacy, and lack of institutional support. Overall, the willingness to change to newer teaching methods has been inconsistent.

A new pedagogical approach called flipped teaching (FT) was proposed in the last decade (Alpaslan et al., 2015; Mzoughi, 2015), although FT's concept is not entirely new (Baker, 2000; Strayer, 2007). The Flipped Learning Network (2014) defines FT as

> a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter.

FT has been shown to enhance the learning environment and is gaining steady traction in the education community in recent years (Love et al., 2014). FT may be advantageous because it creates a classroom environment in which the learner is actively engaged in rich discussion and earnest peer collaboration. In contrast to the traditional teaching method, FT is a well-structured instructional design that reverses homework and classwork. Students practice lower-order thinking skills such as memorization and repetition (Newman et al., 2016) before entering the classroom (Ellis et al., 2006). This practice requires the instructor to prepare lecture videos, assign readings and other valuable resources, and make the content accessible to the

students via an online learning management system with ample time for review. Shifting the lecture to outside the classroom not only allows the students to progress through the content at their own pace, but is also ideal for diverse learning abilities (McLaughlin et al., 2014).

The FT method has become more prevalent in STEM (Wibawa & Kardipah, 2018) classrooms and has shown promising results for improving student-teacher interaction (McLean et al., 2016), content understanding (Love et al., 2014), and student engagement (Gilboy et al., 2015). In this model, the course content is usually delivered using asynchronous and synchronous delivery methods through online lectures and interactive activities. The FT method is based on principles that are ideal for online learning, and studies have shown a strong, direct correlation between the time students spend on a computer or a mobile device and their final grade when using the FT model (Newman et al., 2016).

Furthermore, in the FT method, students can consume the material when they are most alert and motivated, which is far more conducive to subject matter mastery (Hamdan et al., 2013). The students' drive to be successful will persuade and incentivize them to attend class meetings prepared, and thus FT promotes self-efficacy (Olaniyi, 2020). Additionally, students can strengthen and fortify their thinking through enlivening group work with their contemporaries. This cooperative approach to learning produces a more prosperous, livelier classroom and reflects the workplace environment (Newman et al., 2016). Summative assessment studies indicate that FT leads to greater student performance improvement than the traditional teaching method, and many students prefer FT courses (Bishop & Verleger, 2013). For these reasons, some universities have adopted FT in their STEM courses (Catchpole, 2015).

Despite the numerous advantages of the flipped classroom over the traditional learning-based method, several studies remained skeptical of the flipped classroom. Chen et al. (2018) conducted a meta-analysis to compare the efficacy of the flipped classroom paradigm to traditional lecture-based learning. For higher-level learning outcomes, the results showed that the flipped classroom method is associated with higher academic achievement than the lecture-based learning strategy. However, due to the considerable methodological variation, statistical heterogeneity, and danger of bias in the studies used, the results should be regarded with caution. To further evaluate the differences between flipped classroom and lecture-based learning, future studies should have a high level of methodological rigor, a standardized flipped classroom format, and evaluation methods for higher cognitive learning and behavior modification. Gillette et al. (2018) analyzed the evidence of the efficacy of flipped classrooms against traditional lectures. Despite the lack of prospective, randomized trials, the meta-analysis suggests that the flipped classroom may result in little gain in student understanding when compared to traditional lectures. van Alten et al. (2019) conducted meta-analyses comparing flipped versus non-flipped classes in secondary and postsecondary education. They discovered a slight beneficial impact on learning outcomes but none on student satisfaction with the learning environment. Meta-regression, which was done by Vitta and Al-Hoorie (2020) showed that this method was only slightly less effective with longer treatments. They examined the implications of these findings and suggested that future research should investigate not only whether flipped learning is beneficial but also when and how to enhance its effectiveness.

The widespread fallout surrounding the current pandemic displaced students and teachers from academic institutions and necessitated online learning (Yen, 2020). Online teaching before COVID-19 was limited to selected programs and students, where some faculty had the experience and others had never taught online. The formats of online teaching can be either asynchronous or synchronous. Synchronous teaching aims to interact with students in a real-time setting through technological "live" meeting tools (e.g., Zoom, GoToMeeting). On the other hand, the asynchronous approach allows instructors to deliver course materials by uploading them to the course platform and students to study at their own pace, where student-instructor interaction is limited to emails and discussion forums (Hrastinski, 2008). Studies show that implementing online teaching proves to be effective as it provides a student-centered learning environment (Grieve et al., 2017; Ituma, 2011).

The most common teaching strategy during COVID-19 was to transform the traditional teaching format to the asynchronous format (Gillis & Krull, 2020). However, this transformation does not guarantee that student learning is achieved and benefited from online teaching (Greener, 2020). Despite the apparent benefits of integrating FT to traditional teaching, some questions need to be answered while adapting the FT strategy in an online format. The specific questions that will be addressed in the present study are:

RQ1: Did the use of FT before COVID-19 help students transition from face-to-face to remote learning?

RQ2: Which delivery method helped students with this transition and adjustment more, synchronous or asynchronous?

RQ3: Did a faculty member's level of FT experience affect the student transition to online learning?

Answering these questions is significant because knowing if FT helps students with a smooth transition is

critical to understanding what methods we must adopt to help students succeed in this unprecedented situation. The results have implications for reopening campuses and future course planning, including the combination and types of formats needed to ensure greater academic success. Furthermore, the findings of the study may be used to provide opportunities for instructors and administrators to develop long-term goals and discover teaching practices that are appropriate for an educational environment that is rapidly evolving.

Method

Study Participants

The Institutional Review Board approval was obtained from both institutions (IRB# 35), Southern Illinois University–Edwardsville and St. Louis Community College. This study was undertaken in flipped STEM classrooms. A total of 24 faculty participants were recruited in two groups (Cohort 1 and Cohort 2) to receive six faculty development FT workshops that were spread over a semester. Cohort 1 consisted of 12 faculty members from two institutions, six faculty from a community college, and an additional six participants from the public university. Twelve faculty members started implementing FT in Spring 2019 following training in the previous semester (Fall 2018). There were at least two rounds of implementation, depending on whether the faculty member taught during the Summer semester or not. Cohort 2 also consisted of 12 faculty participants who received FT training over one semester (Fall 2019). They had started their first FT implementation in the Spring semester but were forced to switch to online teaching halfway through due to the COVID-19 pandemic. Given the various lengths of experience with FT implementation, Cohort 1 was classified as "developing," while Cohort 2 was classified as "novice," since the faculty in this cohort were beginning their first semester with FT.

When the pandemic hit the world in early March, the Spring semester was halfway through, and students were being taught in all STEM classrooms utilizing the FT method. The pandemic forced faculty in these classrooms to adapt their FT techniques to a completely remote setting. A survey was administered to these students at the end of the Spring semester between the end of April and early May to capture their attitudes and experiences with the rapid transition.

In this study, 265 students from two separate institutions with varied STEM majors and years in college participated. At the beginning of the Spring 2020 semester, there were 378 students in Cohort 1 and 600 in Cohort 2. Due to the fact that the survey window occupied time before and after semesters ended, only 52 (13.7%) students from Cohort 1 and 213 (35.5%) from Cohort 2 participated in the survey. Table 1 provides an overview of the research participants' demographics. Two hundred and thirty-eight students (89.8%) from a public doctoral/professional university and 27 students (10.1%) from a community college are included in the research.

Fifty-two respondents (19.6%) were taught by faculty members in Cohort 1 (developing FT skills), and 213 (80.4%) were taught by Cohort 2 (novice in FT). The majority of the student respondents (n = 188 of 265; 70.9%) were female. Academic standing ranged across all levels: freshmen (n = 100; 37.7%), sophomores (n = 79; 29.8%), juniors (n = 45; 17.0%), and seniors (n = 41; 15.5%). The majority of students identified as Caucasians (79.2%). The course format was almost evenly split between synchronous and asynchronous teaching methods, with 137 (51.7%) students taught in the synchronous format and 128 (48.3%) students taught in the asynchronous format.

The majors of students from the public university included Nursing (n = 74; 32%), Pharmacy (n = 25; 11%), Elementary Education (n = 21; 9%), Biology (n = 21; 9%), and Engineering/Computer Science (n = 26;11%). The majors of students from the community college included Engineering/Computer Science (n = 9; 31%), Nursing (n = 3; 10%), and Animal Science/Biology (n = 3; 10%).

Survey Design and Data Collection

Using the commercial survey platform Qualtrics, an online survey was designed by co-authors to capture information regarding students' experiences with the switch to remote learning during COVID-19. Data was collected via purposeful sampling. The completion of the survey was voluntary, and the survey was open for 20 days. The anonymity statement in the survey was ensured, as well as the security of the data.

Three- or 5-point Likert scales were used to rate students' level of experience with online learning before COVID-19 (1–3, 1 = none, 2 = some, and 3 = extensive); difficulty in adjusting to the online format (1–3, 1 = it has been difficult, 2 = still adjusting, 3 = adjusted very well); difficulty in transitioning to a fully online course (1–5, 1 = much more difficult, 2 = difficult, 3 = neutral, 4 = easier, 5 = much easier); and level of confidence in completing the course that they were taking in the online format (1–5, 1 = not at all confident, 2 = not confident, 3 = neutral, 4 = confident, 5 = very confident). Participants were also asked to explain in an open-ended response how they were adjusting to the online format and transitioning to a fully online class. To strengthen face and content validity, course instructors reviewed and tested the survey, providing feedback to the team on functionality and clarity of language. The final version of the survey included four close-ended and two open-

Table 1
Characteristics of the Study Participants

Characteristics	Total	Cohort 1	Cohort 2
Total participants	265 (100%)	52 (19.6%)	213 (80.4%)
Gender			
Male	77 (29.1%)	31 (60.0%)	46 (21.6%)
Female	188 (70.9%)	21 (40.0%)	167 (78.4%)
Age (years)			
18–19	119 (44.9%)	7 (13.5%)	112 (52.6%)
20–21	83 (31.3%)	19 (36.6%)	64 (30.0%)
22–23	29 (10.9%)	11 (21.1%)	18 (8.5%)
24–25	16 (6.0%)	6 (11.5%)	10 (4.7%)
>25	12 (4.5%)	5 (9.8%)	7 (3.3%)
Blank	6 (2.3%)	4 (7.6%)	2 (0.9%)
Race/Ethnicity			
Caucasian	210 (79.2%)	37 (71.5%)	173 (81.2%)
African American	24 (9.1%)	7 (13.2%)	17 (8.0%)
Asian	10 (3.8%)	2 (3.8%)	8 (3.8%)
Hispanic/Latino	6 (2.3%)	3 (5.8%)	3 (1.4%)
Native American	1 (0.4%)	1 (1.9%)	0 (0.0%)
Multiple	9 (3.4%)	2 (3.8%)	7 (3.3%)
Blank	5 (1.9%)	0	5 (2.3%)
Institutions			
Public University	238 (89.8%)	37 (71.2%)	201 (94.4%)
Community College	27 (10.2%)	15 (28.8%)	12 (5.6%)
Academic Standing			
Freshman	100 (37.7%)	13 (25.0%)	87 (40.8%)
Sophomore	79 (29.8%)	9 (17.3%)	70 (32.9%)
Junior	45 (17.0%)	8 (15.4%)	37 (17.4%)
Senior	41 (15.5%)	22 (42.3%)	19 (8.9%)
Course format			
Synchronous	137 (51.7%)	22 (42.3%)	115 (54.0%)
Asynchronous	128 (48.3%)	30 (57.7%)	98 (46.0%)

ended questions. In addition to this qualitative and quantitative data, the survey gathered student demographic information, including age, gender, race, major, institution, academic standing, and course format.

Data Analysis

Descriptive statistics, including medians and frequencies for participants' responses, were generated using PROC UNIVARIATE of SAS (Version 9.4; SAS Institute, Inc., Cary, North Carolina). For the quantitative analysis, evaluation focused on students' perceptions of online learning and FT (Table 2) and whether those perceptions differed by cohort or other demographic factors. The favorable perception was defined as a score of 4 or higher on a 5-point Likert scale or a score of 3 on a 3-point Likert scale, indicating that these scores reflect positive reactions within each category. Initial analyses indicated that the different cohorts exhibited different variation patterns, which would have violated model assumptions had the cohorts been analyzed simultaneously. Due to differences in model factors between cohorts and the difference in sample size, the two cohorts were compared using a test of proportions. The difference in frequencies of favorable responses were compared using two samples Z Proportion test via the "prop. test" function in R (Version 3.5.2) (R.Core.Team, 2018). The effect of individual

demographic variables on the expected outcome of the dependent variables ("online:" experience with online learning before COVID 19; "adjust:" adjusting to the online format; "transition:" transition to a fully online class with FT experience; and "confident:" confidence level in completing the course in the online format), recoded as previously described, was tested using logistic regression in PROC GLIMMIX of SAS (Version 9.4; SAS Institute, Inc., Cary, North Carolina).

Open-ended questions were analyzed using a qualitative data analysis software package, NVivo™, produced by QSR International. The process of identifying themes from the data collected involved breaking down each student's response into meaningful phrases or sentences using open coding. Categories were then identified and used to find central themes that emerged from the data. A team of four coders individually analyzed the data to increase validity. The coding team's regular meetings provided time for discussion about all coding levels, particularly about data inconsistent with the evolving categories.

Results

Quantitative Analysis

The survey asked students to rate their experience, adjustment, FT effect, and confidence in areas identified by investigators as important for the transition from traditional learning to a remote learning environment. Their responses are presented in Table 2.

Gender, school, class level, and race were all factors included in the logistic analysis of the responses to four survey questions. The F-values and P-values for the participants' responses from Cohorts 1 and 2 are presented in Tables 3 and 4, respectively. As shown in Table 3, there were no differences in perspectives among the various student groups in Cohort 1. However, there were three significant differences of note for Cohort 2, as shown in Table 4. The asynchronous students reported more favorable responses in Cohort 2 for both the ratings of transition and adjustment, suggesting that asynchronous learning methods are more advantageous for students with limited online learning experience. These observations were valid regardless of race, school (community college or 4-year institution), gender, or class level within their respective schools.

Given the difference in the pattern of variation of the two cohorts, for at least three of the four questions, it is inappropriate to pool responses, and the inclusion of interaction terms resulted in confounding and lack of convergence of the model. Therefore, the cohorts were modeled separately. A test of proportions was conducted to demonstrate the true difference between the cohorts for each of the four dependent variables. As seen in Figure 1, the results showed that students from Cohort 1 reported significantly more favorable perceptions of their transition ($p<0.01$), confidence ($p<0.01$), and adjustment ($p<0.01$), but there was no significant difference between cohorts in their experience with online learning before COVID-19 ($p = 0.30$).

As seen in Figure 2(a), the course format influenced student perceptions of the transition. Only 17.3% of synchronous students reported a favorable adjustment, compared to 37.8% of asynchronous students ($p<0.01$). Likewise, only 22.7% of students from synchronous classes reported a favorable transition to online learning, whereas 42.9% of asynchronous students reported a favorable transition ($p<0.01$). Again, there was no evidence to suggest that this response differed by race, class, gender, or school. Only 15.3% of Cohort 1 and 12.7% of Cohort 2 reported a favorable (extensive) online experience. There were no differences between students in both cohorts regarding their online learning experience prior to COVID-19. Although there was no effect of mode that explained differences in student confidence ratings, gender played a significant role here. As seen in Figure 2(b), male students were significantly more confident in their course completion than female students, with percentages of 71.7% and 50%, respectively ($p = 0.03$).

Qualitative Analysis

Qualitative data was collected to further evaluate students' perceptions associated with the sudden transition during COVID-19 and its perceived effects. The researchers analyzed the similarities and differences between the interview responses. The qualitative analysis revealed six main themes encompassing participants' perceptions about transition. This data was then organized into two key categories. These were both positive and negative encounters with FT. The positive experiences included: FT helped in online transition because of self-pace and flexibility and communication. The negative experiences included: lack of instructor presence, increased workload, lack of motivation, and challenge with technology and physical environment. Participants' good experiences were helped by having easy access to course materials, a user-friendly course website, support from the institution and instructors, and a flexible participation schedule. Negative participant experiences were caused by instructors who did not provide sufficient or timely feedback, a lack of technical support, a lack of contact between students, and a poorly organized course materials.

The following research questions were resolved through data collecting and analysis: 1) how prior exposure to FT aided or hindered their transition to a fully online mode of learning; and 2) how they adapted

Table 2
Students' Rating Responses

	Total		Cohort 1		Cohort 2	
Question	Frequency	Median	Frequency	Median	Frequency	Median
1. Rate your experience with online learning prior to COVID 19:						
None (1)	71	2.00/3.00	11	2.00/3.00	60	2.00/3.00
Some (2)	159		33		126	
Extensive (3)	35		8		27	
2. How are you adjusting to the online format?						
It has been difficult (1)	93	2.00/3.00	10	2.00/3.00	83	2.00/3.00
Still adjusting (2)	91		18		73	
Adjusted very well (3)	81		24		57	
3. Having had the experience with flipped teaching method my instructor used prior to spring break, my transition to a fully online class has been:						
Much more difficult (1)	17	3.00/5.00	2	4.00/5.00	15	3.00/5.00
Difficult (2)	50		4		46	
Neutral (3)	99		15		85	
Easier (4)	74		20		54	
Much easier (5)	24		11		13	
4. How confident are you in completing this course in the online format?						
Not at all confident (1)	13	4.00/5.00	1	4.00/5.00	12	4.00/5.00
Not confident (2)	32		3		29	
Neutral (3)	64		6		58	
Confident (4)	96		18		78	
Very confident (5)	60		24		36	

Table 3.
Analysis of Participants' Responses in Cohort 1

Effect	Degrees of freedom	Transition		Confident		Online		Adjust	
		F-Value	P-Value	F-Value	P-Value	F-Value	P-Value	F-Value	P-Value
Gender	1	2.85	0.10	0.49	0.49	0.00	0.98	0.03	0.86
Class (School)	7	0.33	0.93	0.22	0.98	0.06	1.00	0.83	0.57
Mode	1	0.94	0.34	1.20	0.28	0.04	0.85	0.20	0.65
Race	5	0.69	0.64	0.02	1.00	0.00	1.00	0.02	1.00

Table 4.
Analysis of Participants' Responses in Cohort 2

Effect	Degrees of freedom	Transition		Confident		Online		Adjust	
		F-Value	P-Value	F-Value	P-Value	F-Value	P-Value	F-Value	P-Value
Gender	1	0.05	0.82	4.95	0.03	1.40	0.24	0.22	0.64
Class (School)	6	0.81	0.56	0.92	0.48	0.77	0.60	0.59	0.74
Mode	1	9.46	<0.01	0.65	0.42	0.14	0.71	10.10	<0.01
Race	4	0.01	1.00	0.69	0.60	0.86	0.49	0.92	0.45

Figure 1.
The Difference in Percentage Approval Between Cohorts by Topic

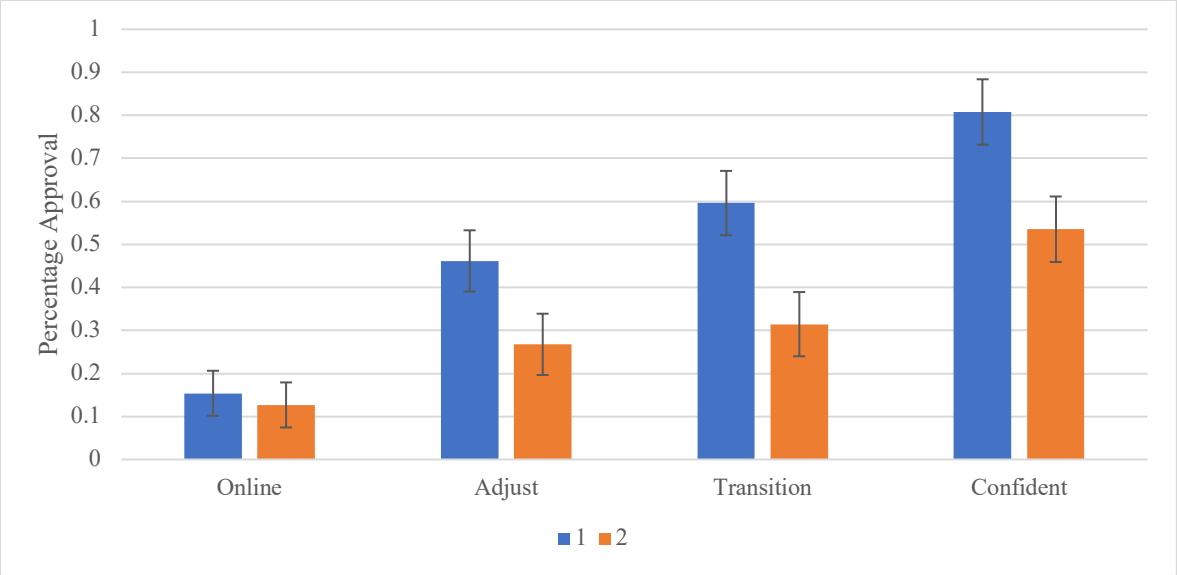
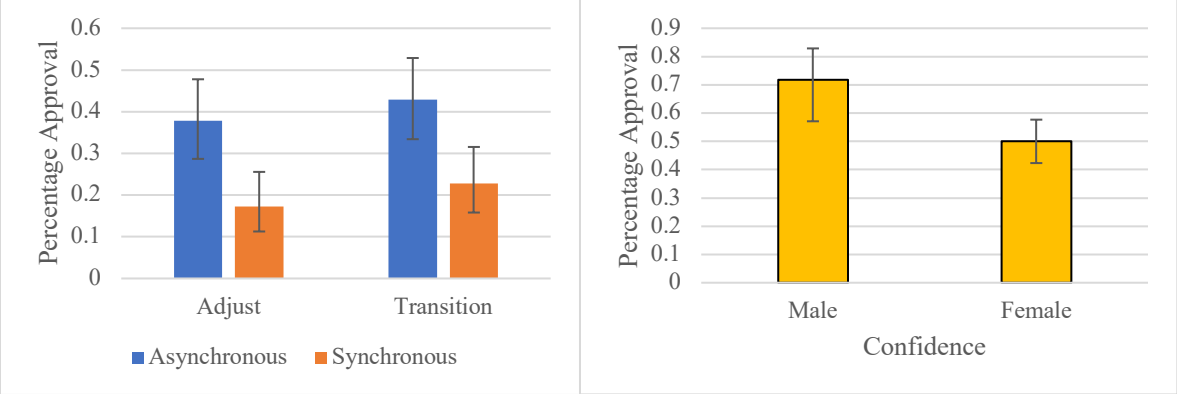


Figure 2.
The Difference in Percentage Approval by (a) Mode of Delivery and (b) Gender



(a) (b)

to the online format during the sudden switch from FT to a fully online method due to COVID-19.

Positive experiences and contributed factors:

(1) Flipped teaching helped in online transition: Due to the fact that course materials were previously prepared for students during flipped teaching, the flipped teaching format helped students for sudden transition to online format. This was the most influential aspect in participants' favorable experience. A total of 102 out of 265 students from both cohorts [Cohort 1: 31 students (59.6%) and Cohort 2: 71 students (33.3%)] expressed that their transition to sudden online learning was not difficult. "Since [the professor] had already implemented online videos and learning, it was much easier to transition. I already knew how he was going to have everything set up, and it was convenient." "Having already done the flipped lectures made knowing the expectations of the class much easier. The instructor made everything extremely easy for us to transition, especially since we already had the experience with her flipped online style before COVID."

The ability to study at your own pace is another positive aspect of this study. Students liked the fact that they could set their own pace for learning. Participants had complete discretion about when they studied required knowledge material supplied by the instructor. “You are free to work at your own pace..."

(2) Communication: Good communication and organization are two of the most crucial abilities for implementing flipped teaching. These skills enable teachers to maintain order in the classroom and maximize student learning possibilities. A total of 45 students from both cohorts [Cohort 1: 8 students (15.3%) and Cohort 2: 37 students (17.3%)] felt that the communication and organization skills of their professors helped during the transition. "I feel that the transition has been very smooth. Good clear communication between students and professors." Students considered that the good communication skills exhibited by the instructors made for a positive experience because they made expectations clear and provided prompt feedback. "From the modules, I can watch recorded lectures and locate tasks and expectations." Another student cited, "It was helpful to view not only weekly assignments but also a list of all lectures and supplementary materials.” The student said, “it was a pleasure to have access to this information."

Negative experiences and contributed factors:

(1) Instructor presence: Students in this study experienced a sense of isolation for a variety of reasons. The absence of interpersonal discourse or engagement between professors and students was one issue. Forty-one students expressed [Cohort 1: 6 students (11.6%) and Cohort 2: 35 students (16.4%)] their need for instructors to guide them and to provide a structure for them to work within. "With no in-person communication, it was difficult at times to connect to the material and instructor." A few students also reported missing peer interaction. "I cannot learn on my own. I need a classroom environment." The tedious instructional methods employed in the flipped classroom further contributed to the sensation of isolation. Participants in this study said that their instructor used *only* the discussion board for communication and interaction. "We exclusively interacted via discussion boards. He (the instructor) will not respond to our email.”

(2) Increased workload: 76 students [Cohort 1: 6 students (11.6%) and Cohort 2: 70 students (32.8%)] mentioned that they were not able to keep up with the workload. The common notion was that there were too many due dates to follow, and often they missed some assignments due to this challenge. "I have never been one for online teaching and learning. I have always preferred to do things in class and have a teacher teach us because I think I learn and retain everything better in class and person." "Online classes are still difficult, and flipped teaching was just a pain. More stressful than helpful."

(3) Lack of motivation: While students appreciated the flexibility and convenience of flipped teaching, they were also required to take responsibility. Due to the flexibility and convenience of courses, self-control and self-motivation are essential for student success. When a student lacks self-control, he or she may miss the due dates for homework or even the test dates. Thirty-six students from both cohorts [Cohort 1: 12 students (23.07%) and Cohort 2: 24 students (11.2%)] expressed that they were less motivated, less engaged, and less focused during online learning. One student expressed that "Lecture is not as engaging or interesting due to a lack of personal interactions." He was unable to communicate with the instructor in any way, which also contributed to his unpleasant experience. “You need to be really self-motivated and focused. I am frequently sidetracked and living at home has rendered me extremely unmotivated."

(4) Challenge with technology and physical environment: The absence of an Internet connection is the fourth negative experience identified in this study. The absence of a computer and an Internet connection prevents students from accessing their online courses. Because they lacked internet access at home, they had to travel to public locations to access their online courses. Some students therefore struggled [Cohort 1: 5 students (9.6%) and Cohort 2: 25 students (11.7%) with a lack of technology to cope with online learning. "I have a very limited source of internet, and I had to share it with my younger siblings." Others mentioned their challenges being at home and not having the classroom setting to learn. "My preferred learning style is not from a computer screen."

Discussion

The study was set to examine if: 1) the FT method, that had already been adopted before COVID-19, helped students' transition from the face-to-face class environment to remote environment, and 2) either of the delivery methods, synchronous or asynchronous, were more helpful with the transition and adjustment; and 3) whether a faculty member's level of FT experience affected the student transition to online learning.

Overall, our findings indicated that a sizable proportion of students from both cohorts indicated that transitioning to sudden online learning was not challenging. While quantitative analysis revealed no significant variations in viewpoints across the various student groups in Cohort 1, students in Cohort 2 had substantial variances in transition and adjustment scores. In Cohort 2, students enrolled in the asynchronous format expressed more favorable attitudes toward transition and adjustment, suggesting that asynchronous learning approaches are more helpful for students with limited online learning experience. The format of the course had an effect on students' views of the transition. Only a small group of synchronous students reported a positive adjustment, whereas two-thirds of asynchronous students reported a pleasant adjustment.

Similarly, just a small percentage of synchronous students experienced a pleasant transition to online learning compared to almost half of asynchronous students. Although it is unknown why there are no differences in students' perspectives in Cohort 1, the finding in Cohort 2 is consistent with previous research indicating that students can benefit from the integration of lecture videos, course materials, and activities prior to meeting with their instructors and peers (Abuhmaid & Abood, 2020). Furthermore, results from this study also confirms that online learning efficiency with the synchronous format was unsatisfactory among students (Tang et al., 2020).

Additionally, no significant difference in online learning experience existed between cohorts prior to COVID-19; both cohorts reported extremely low favorability ratings, with only some students from Cohort 1 and Cohort 2 reporting extensive online experience, but students from Cohort 1 reported significantly more favorable perceptions of their transition, confidence, and adjustment. Instructors with extensive FT training might have been the reason that students from Cohort 1 reported more favorable perceptions of those three variables. The Cohort 1 instructors were well trained in communication, developing class activities for active learning, pedological mode, and student support. These four factors might have influenced students' readiness for their transition, confidence, and adjustment. For example, effective communication between instructors and students might have helped students understand their needs and expectations, resulting in a smooth transition and adjustment. Instructors might have also impacted students' transition and adjustment with pedagogical support by providing learning activities that involved class activities regardless of the online mode. Monitoring students' needs and providing timely feedback, especially for those struggling, might have also helped students' confidence.

Although there was no effect of mode that explained differences in student confidence ratings, gender played a significant role. Male students were significantly more confident in their course completion than female students. This result might be explained by previous work indicating that female students are less confident in their math and science ability than male students (Sterling et al., 2020). The confidence gap by gender in STEM has been previously reported (Correll, 2004).

The qualitative component of this study allowed for a deeper exploration of the students' experiences. Overall, the students in all groups expressed very similar benefits and challenges. Approximately two-thirds of students indicated that their transition to sudden online learning was not challenging. In the FT model, students were aware of how and when instructors would cover the course materials because instructors had already made learning materials available over the schools' intranet system. Several students reported that the FT model aided their academic progress for a variety of reasons, including the ability to regularly review recorded class videos and concentrate more effectively when studying alone.

Regarding student adjustment to the online format, some students expressed that instructor presence and communication with their instructors helped them adjust to the online format. This finding resonates with earlier research stressing establishing a presence which is closely connected to the instructor's ability to create a sense of community among learners in an online course (Palloff & Pratt, 2011). Online learning requires a shift from a teacher-centered environment to a student-centered one where the instructor must take on multiple roles. The constructivist theory, that supports online learning, demands that instructors become more than dispensers of knowledge; they become instructional designers, facilitators, and assessors of both grades and their teaching methods (McQuiggan, 2007). However, almost two-thirds of students perceived that they could not keep up with the workload, there were too many due dates to follow, and admitted that they missed some assignments. This result is also consistent with published literature. For example, Paas et al. (2008) found that cognitive load and instructional inefficiency were high for non-interactive learners, such as in the asynchronous model compared to interactive teaching methods.

Our qualitative analysis results also showed that only a small percent of students expressed that they were less motivated. A possible reason for this result might have been a lack of community or peer interactions in the online format. There is a significant correlation between a student's success and a perceived sense of community provided by the campus community or students' peers (Wiseman et al., 2004). The sense of community is typically developed by students remaining at a school for a period of time and interacting with other students, instructors, and the curriculum. However, online learning might reduce the sense of community of freshmen and sophomores that are new to the campus since this decentralized learning environment results in the potential to lead to isolation, loneliness, and lack of motivation in the online learning model. Additionally, some students offered enhancements to address areas of discontent, including increasing network stability, engaging interactions through holding face-to-face sessions for hands-on classroom activities which are crucial in the STEM field.

Schlesselman (2020) argues that the probability of future crises demanding the use of online learning is high. Additionally, Van de Vord (2012) alleged that certain components of online education need significantly more time per student than the in-person instruction. As a result, instructors and administrators should carefully consider implementing a more methodical and well-planned approach to learning, such as the FT model, into their current face-to-face sessions in order to capitalize on the FM model's benefits for sudden adjustments.

Limitations of the Study and Future Research

The results of this study showed that instructors with prior flipped classroom experience were more engaged in the classroom, and students who had previously interacted with flipped classrooms were able to rapidly adjust to online learning. However, this study did not look at specific experience of front-line teachers or the measures the instructors should take to ensure that students who have not been exposed to flipped classes are prepared for their classes.

Furthermore, this study did not assess students' learning or the perceptions of their own achievement in terms of course grades. In addition, the study did not take into account the activities that were integrated into classes by the instructors from both cohorts. Another limitation is that the study was conducted between a local public institution and a community college because of the short time frame available for designing and implementing the study. As a result, the findings of this study cannot be applied to a larger population. Also, the confidence gap by gender in STEM has been previously shown. This study, however, did not compare the level of confidence among STEM majors. We also did not consider whether the differences were due to the student's major.

Despite these constraints, the study gives valuable insights about the FT method as well as online learning environments. As a result of the findings that FT helped students adjust to online learning, future online teaching could incorporate FT features, particularly the synchronous portion of FT, in order to engage students in active learning and interaction with their classmates. Because this study was conducted during the very early stages of the COVID pandemic, when students and educators were compelled to make rapid adaptations, subsequent studies will examine student responses to online learning 6 months and 1 year after the outbreak of the COVID pandemic.

Conclusions

With the addition of an online component, this study contributes to the current body of knowledge on the research of teaching through the flipped classroom approach. To be more explicit, the study provides three significant advances in knowledge. In the first instance, many students stated that FT assisted them in making the transition from traditional classroom learning to fully online learning without interruption because the course materials, lecture recordings, and other learning resources were already available through the course management systems. Second, the results indicated that instructors that had received thorough FT training and deployed FT in semesters prior to the COVID-19 pandemic were better able to assist their students in making a smoother transition and adjustment to completely online learning environments. Finally, students who were taught by instructors that were familiar with FT tended to prefer the synchronous format, whereas students who were taught by instructors who were inexperienced with FT tended to prefer the asynchronous format. In general, advanced planning and effective communication between course instructors and students were critical to students' success in the transition to an online learning environment.

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