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Addressing the Needs of Hispanic/Latino(a) Students with the Flipped Classroom Model

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I. Introduction

Modern students are increasingly *non-traditional*. Definitions vary, but it generally refers to postsecondary students who meet some of the following criteria: being older than 25 years old, having a gap between post-secondary education and high school graduation, being financially independent from their parents and having dependents. These conditions require them to work full or part-time while pursuing their degree. This presents a significant challenge, as balancing work and school lead to increased stress, fatigue, and a reduced ability to focus on academics [1]. In some cases, students may drop out due to the demands of their job. According to the National Center for Education Statistics (NCES), many university students in the United States are non-traditional. Despite these challenges, non-traditional students excel because they understand the value of a college degree in today's job market, particularly for certain engineering disciplines where a degree is required.

Hispanic/Latino(a) students are often non-traditional and face unique challenges and obstacles in their pursuit of their degree. Hispanics/Latino(a)s are more likely than other demographic groups to work while attending college [2]. The high rate of labor force participation among Hispanic/Latino(a) students can be seen as an example of intersectionality [3], as it is influenced by multiple factors, including their race, ethnicity and socio-economic conditions. The disproportionate burden of work faced by Hispanic/Latino(a) university students is a form of inequity that highlights the interconnected and overlapping nature of social categories and their impact on retention in higher education. Addressing these systemic challenges requires a nuanced understanding of the context of Hispanic/Latino(a) non-traditional university students. We are motivated to study instructional strategies for individuals who are unable to dedicate long and uninterrupted periods to prepare for class due to their workload—which they must prioritize over academics due to their context.

One strategy that may address the needs of Hispanic/Latino(a) non-traditional students is the flipped classroom (FC), a technique dating to a work in 2000 by Lage et al. [4]. Students are assigned short videos to watch on their own time outside of class, rather than conventional textbook readings. During lecture, students complete activities that would normally be considered homework in conventional classroom models, as a social learning activity. This addresses the needs of individuals who work, as videos can be paused and revisited at a later point. However, it is not clear if dialogic and active-learning activities are effective for Hispanic/Latino(a) students [5]–[7], or improve their academic outcomes versus other demographics [8]. This work presents the results of study since 2020, involving 123 students across 9 sections of Computer Science and Electrical & Computer Engineering courses. Most of the data was collected during the COVID-19 pandemic, when courses were required to be online. Responses from attitudinal surveys are analyzed to determine if Hispanics/Latino(a)s opinions about their experience with FC are different from a general population. Our findings indicate that Hispanics/Latino(a)s distinctly, as compared to a general population, find FC activities to be more engaging, and can better engage prior knowledge. This seems to contradict literature.

Further, a general analysis finds that FC may not be well suited to courses where it is difficult to condense pre-lecture expectations into twenty-to-thirty-minute micro lectures. We describe our instructional strategies in great detail so that they can be reproduced, in hopes that others continue studying variations of FC to improve their effectiveness for the context of Hispanic/Latino(a) non-traditional students.

II. Background

Two decades of work demonstrated FC to be an effective instructional strategy for postsecondary education [9]–[11], and it continues to be an active area of research. A study by Shraddha et al. [12] applied FC to electrical and computer engineering courses and found that the students' self-reported problem-solving abilities improved, with over 90% of participants in agreement. Unlike other works the instructional strategy included post-activity quizzes, and students could still attend conventional lectures. Dori et al. [13] combined FC with outside-of-class activities for additional active learning opportunities. It built on the established project-based learning (PBL) technique [14], and those who participated in the PBL activity had a slight but statistically significant improvement in academic performance.

Bhat et al. [15] applied FC to a graduate-level course in Android and mobile application development. The study leveraged the NPTEL e-learning platform as a repository of recorded lectures. The instructors included additional videos with guidelines and expectations for in-class activities. No pre-activity quiz was included, although NPTEL provided standardized quizzes—it is not known if the study required students to complete them. Attitudes toward FC were gauged with a Likert question and mostly positive. Subramaniam and Muniandy [16] applied FC to an information systems class in a pre-university program. Their work included a comparison to a didactic control group. There was no pre-activity assessment and they did not find any statistically significant difference between control and FC groups. Lopes et al. [17] conducted a four-year study on FC with graduate-level courses at two universities. The study had a large sample size and employed statistical analysis (ANOVA and Mann-Whitney U-tests) to study Likert responses. Participants reported mixed or neutral attitudes toward FC. But, the specific classes involved, strategies for curating videos, and pre- or post- assessment protocols are not given.

A well cited study by Maher et al. [10] implemented FC in four information systems courses and found positive outcomes. Implementations and interpretations of FC varied greatly even within the study, as with the brief survey of literature. Generally FC is described as follows:

- Students watch videos outside of class to prepare them for in-class activities [15], such as instructor-created videos [18], YouTube [19] or MOOCs [15].
- In-class activities are constructivist, dialogic learning activities, often in groups [12] or pairs [10].
- There is some form of assessment before and/or after the activity, such as pre-lecture quizzes [10], post-lecture quizzes [12].
- Some works include requirements of a traditional classroom such as post-activity homework [19], post- activity group activities [13], and assigned reading from the textbook [10].

According to a literature survey of 32 works, many studies do not explain their instructional strategy in a way that can be reproduced by others [11]. We contribute the following to state-of-the-art by:

1. Describing an implementation of FC in a reproducible way.
2. Assessing Hispanic/Latino(a), and/or non-traditional students' attitudes toward FC.

It is not clear if dialogic instructional strategies such as active learning are effective for all demographic groups, such as Hispanic/Latino(a) populations [5], [6]. In a single section of undergraduate databases, Rueda [19] found that FC was positively received by a Hispanic/Latino(a) population. A dissertation by Lotto [7] explored the role of engagement with FC for postsecondary ESL English courses and recommended only partially flipping the classroom as a culturally effective best practice. It did not compare outcomes of Hispanic/Latino(a) students to a general population. A comprehensive study by Carter et al. [8] flipped 13 sections of liberal arts Mathematics courses, monitoring test scores across various demographic groups. Black and African Americans had a statistically significant improvement with FC, but Hispanics/Latino(a)s did not. There is no consensus on the effectiveness of the FC for a Hispanic/Latino(a) population.

III. Methods

III.A. Instructional Strategy

To ensure best practices in flipped classroom methods, the team includes a third-person educational researcher (Andrea Medina) focusing on high-impact classroom practices. There are three instructors in the study: Instructor A, Instructor B and Instructor C. Instructor A is the lead instructional designer and learned FC and active learning from the Transforming STEM Teaching Faculty Learning Program (FLP) hosted virtually by the University of California, Berkley. Instructor A has publications in iterations of the flipped classroom model [20], [21]. Instructor C received a grant on diversity-centric learning and project-based learning. Instructor A and C taught years of courses in the flipped classroom modality before the study. Instructor B has less training than Instructor A but is not a significant source of data for the study ($n = 2$ vs. an overall $n = 123$).

This study was supported by a grant that requires evaluation. Formative assessment is monitoring the outcomes of students in the study and informing the team of student attitudes so changes can be made to experimental design. Overall, the team is well trained in the flipped classroom model, and the educational researcher, Instructor A and external evaluator monitor adherence to best practices.

III.A.1. Instructor A and B

Instructor A and B followed conventional FC design [9]. For each activity, students were required to watch *micro lectures* before coming to class. Each activity had one or more micro lectures assigned, not exceeding a total of twenty to thirty minutes. Micro lectures were sourced from YouTube or made from scratch. The micro lectures solved a handful of example problems directly related to the class activity. The instructors created dynamic and engaging micro lectures using the Miro app as an interactive whiteboard or would record themselves solving problems on a physical whiteboard using a high-quality single lens camera and video capture device. OBS software captured the video, and Adobe Premiere improved audio and rendered the videos into MP4 format. Videos were provided on the course learning management system. Modules were organized on a daily basis, with clear instructions on what videos should be watched before coming to class. Supplemental content, such as full-length lecture videos, lecture notes or assigned textbook readings, were provided with the modules. But, students were only assessed on material explicitly in the micro lecture and these expectations were communicated to the students. A pre-activity quiz accompanied each set of micro lectures. As with the micro lecture, the quiz included problems related to the activity. The quizzes had 20 to 30 questions ranging in difficulty from simple questions to check if individuals watched the video, to difficult questions where students must infer knowledge not given in the video.

Before lecture, instructors would carefully select the pairs for group activities based on academic performance, so individuals are matched with others of similar achievement, also known as *within-class homogenous grouping*. Ability grouping produces small but significant improvements in academic performance [22], promotes student learning outcomes [23], and is effective for within-class collaboration [24]. Stratum were determined based on quiz performance, overall performance in the class, and attendance rate.

Lectures began with a short ten-to-fifteen-minute introduction where the instructor completed a few example problems. The introduction was as dialogic and constructivist as possible. For example, the instructor would prompt the class for answers, sometimes soliciting wrong answers and exploring why it was incorrect. The introduction also helped students to identify and engage prerequisite concepts for the activity. Then, students would begin the activity with their assigned partners. The instructor and teaching assistant would walk around the class assisting pairs as needed. Lecture activities were required, it was not possible for an individual to make up the activity except in extreme cases. The activities were graded and factored into their grade in a major way, as a traditional class might regard homework. There were no post-activity homework assignments given in addition to the activity. Lectures, labs and exams were administered in a normal fashion. During the COVID-19 pandemic (all sections except Fall 2022), FC sections were administered online. Instructor A used the Discord app's voice chat and screen sharing to facilitate pair activities. Instructor B used Zoom breakout rooms. Discord is not an ADA compliant program, and Instructor A used Zoom if students with disabilities were present in the section. The university re-opened from the COVID-19 pandemic as late as Fall 2022. A hybrid model was piloted by Instructor A to allow individuals to attend both online and in-person. However, only 2 out of 35 individuals opted to attend the class online.

III.A.2. Instructor C

Instructor C implemented the flipped classroom approach in three different Electrical Engineering courses. Instructional videos covering the concepts were recorded and uploaded into the canvas. In class, students participated in hands-on activities, worked on practice problems, and received individualized attention and guidance from the instructor. Generally, the conventional flipped classroom designs were followed with a few changes as below.

To have a fair grouping system and promote diversity and inclusion, weekly seat rotations were implemented (so that students would sit next to different people each week). Our seat rotations followed a solution to the social-golfer problem—a problem whose task is to schedule $m \times n$ golfers in m groups of n players for w weeks such that no two golfers play in the same group more than once. In other words, a solution to the social golfer problem ensures the quickest way for everyone to meet and work with everyone else in the class.

Each group was asked to send one representative to solve at least one question in front of the class. While not all students are excited about doing engineering problems in front of the class, they can all benefit from being called down to the board. Explaining an answer builds higher-level skills. Having students discuss questions on the board is much more than just what they write. Describing how they found an answer requires higher-level thinking skills and helps students better grasp the concept.

Half of the class activities in Wireless Communications course were designed to be project-based learning (PBL). PBL can help students to apply their knowledge and skills in real-world scenarios, making learning more relevant and enjoyable. PBL encourages students to take an active role in their learning. By working on real-world problems, they engage in hands-on, experiential learning that helps them retain information better. PBL requires students to think critically and apply their knowledge to solve complex problems. This can help to deepen their understanding of the concepts and make the learning experience more meaningful.

III.B. Data Collection, Survey Instrument, and Statistical Analysis

Data collection for this study began in Spring 2020 and an overview of the sections involved in the study is given in Table 1. The study included data from two instructors each from the Computer & Electrical Engineering & Computer Science department and the California State University, Bakersfield. Data was collected from upper-division core courses in Computer Architecture, Signals and Systems, and Artificial Intelligence, and in upper-division elective courses Wireless Communications and Digital Communications.

Table 1: Sections involved in the study. Online: 100% online. Hybrid: Course taught with option for students to attend in person or online. Face-to-face: Students required to physically attend class to complete activities.

Term	Instructor	Course	Nature	n
Fall 2020	A	Computer Architecture	Online	5
Fall 2020	B	Artificial Intelligence	Online	2
Fall 2022	A	Computer Architecture	Hybrid	22
Fall 2022	C	Signals and Systems	Face-to-face	21
Fall 2022	C	Wireless Communications	Face-to-face	11
Spring 2020	A	Artificial Intelligence	Online	16
Spring 2020	A	Computer Architecture	Online	15

Spring 2022	A	Artificial Intelligence	Online	25
Spring 2022	C	Digital Communications	Online	6

The study is exempt from a full IRB review (CSUB IRB 22-92). Participants could consent or not consent to participate. Extra credit was given in some sections as an incentive. However, to avoid coercion, extra credit was also awarded to those who declined to participate or did not fully complete the survey. The collection activity was masked, with documents stating another instructor as the principal investigator. The study normalized biases by administering two surveys, one at the beginning and one at the end of the semester. Individuals who identified themselves as having previously taken a class with flipped classroom are excluded from the data. These surveys included demographic information as well as questions using a 5-point Likert scale. The questions are:

1. I can balance my work hours and lecture time.
2. I need my job more than I need my degree.
3. I often attend class.
4. I can find time to study.
5. The concepts taught during lecture will be useful in my future career.
6. I feel prepared before coming to lecture.
7. I need to seek out material beyond what is provided by the instructor.
8. It is hard to pay attention for a full lecture.
9. I can understand examples covered in lecture.
10. In class, I can identify previous concepts that are important to the task at hand.
11. I am satisfied with the quality and content of lecture activities.
12. I prefer traditional classes over flipped classes.

Questions 1 and 2 directly measure work-life balance. Non-traditional students have workloads that affect their retention and engagement [1]. Questions 3 and 4 indirectly measure work-life balance by assessing factors influenced by the ability to dedicate time to the class. Question 5 measures the perceived utility of the class. Questions 6 and 7 measure engagement outside of class and study behaviors. The remaining questions gauge attitudes towards in-class activities.

Likert questions are prone to biases and limitations. Acquiescence bias [25], response bias due to spatial arrangement [26], and ordinal nature of Likert responses [27] can all impact the validity of the data collected. To somewhat abate these issues, we have collected data over many semesters. Our aim is to have as large a sample size as possible. We also included the following free-response questions to determine the factors or reasoning behind Likert response patterns.

13. Considering your work, life and class balance, what resources are particularly helpful to achieve balance?
14. Can you cite specific features of class or accommodations provided by instructors that helped or introduced barriers to you achieving balance?

15. Can you cite specific events or features of the group activities that were helpful or not helpful?

To analyze the data, we considered descriptive statistics and a non-parametric test (Mann-Whitney U-test) to compare the difference between the pre-survey and post-survey populations [28]. For this work, $p < 0.05$ is considered significant. Statistical analysis was performed variously in Python and Microsoft Excel.

IV. Results and Discussion

The study has a sample size of $n = 123$ and took place at a medium-sized Hispanic-Serving Institution (HSI). Three hundred and thirty-nine out of 564 students in the department (60.10%) are Pell eligible. Most students in the study identify as Hispanic/Latino(a), are Pell eligible, and work 20 hours or more per week. The demographics of the study population, as they compare to the department are given in Table 2. Though the study has less Hispanic/Latino(a) participants than the departmental data, the distribution (rank) is consistent.

Self-reported work hours are given in Figures 1 and 2. Data is bimodal. When aggregated, a majority work more than more than ten hours per week. However, considering single categories, a plurality of students do not work. Aggregating the categories of 20 or more work hours per week, Hispanic/Latino(a)s marginally work more hours than a general population. However, the difference is not statistically significant when applying a Mann-Whitney U-test ($p = 0.395$).

Literature suggests that Hispanic/Latino(a)s work more than other demographics [2], [3]. We are cautious to assert that this contradicts the stance of literature. It can only be said that individuals in this study, drawn from the distribution of students in our programs, tended to work part or full-time regardless of race/ethnicity. The focus of our work is to identify practices to assist Hispanic/Latino(a) students, and our findings may be generally applicable to high-workload students independent of demographics.

Table 2: Demographics of the study population. Dept.: Demographic data, department, AY 2021/22.

Ethnic/racial identification	Study	Dept.
Hispanic/Latino(a)	50.77%	61.43%
White, non-Hispanic/Latino(a)	21.54%	13.93%
Asian	17.69%	12.86%
African American or Black	6.15%	2.50%
Unknown	1.54%	4.64%
Two or more races	1.54%	2.86%
American Indian, Alaskan Native or Pacific Islander	0.77%	1.79%

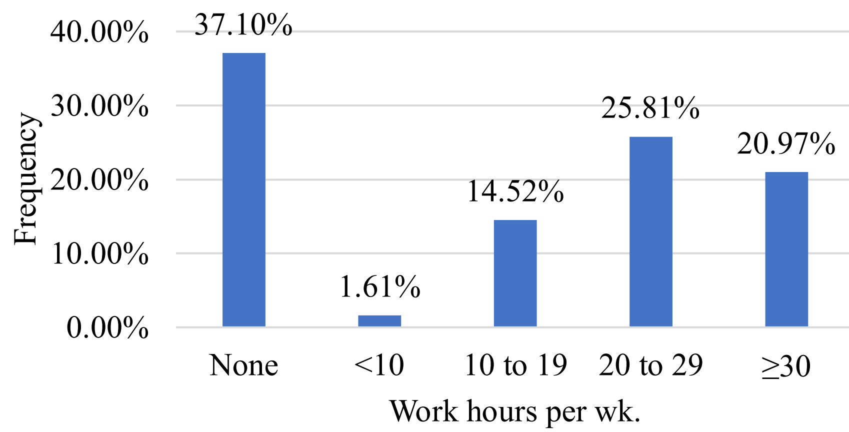


Figure 1: Work hours per week among participants who identified as non-Hispanic/Latino(a) (excluding individuals who declined to identify their ethnicity/race).

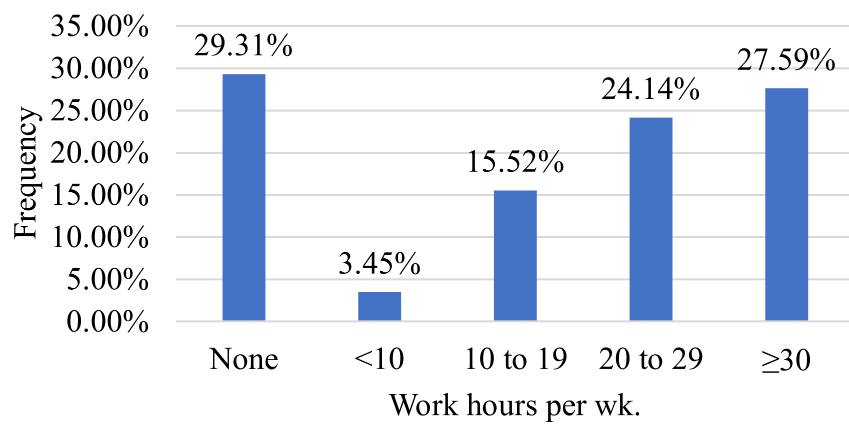


Figure 2: Work hours per week among participants who identified as Hispanic/Latino(a).

IV.A. Survey Results

IV.A.1 Impact on Hispanic/Latino(a) Population

A table of response statistics and testing to determine if pre- and post-survey response were significantly different are given in Table 3. Among the questions asked of participants, three questions produced statistically significant differences between pre- and post-survey responses for Hispanic/Latino(a) populations:

7. I need to seek out material beyond what is provided by the instructor.
8. It is hard to pay attention for a full lecture.
10. In class, I can identify previous concepts that are important to the task at hand.

with only Question 7 being statistically significant for both Hispanic/Latino(a) and general population.

Table 3: Results of survey comparing a Hispanic/Latino(a) population to general one. σ: Standard deviation. f: Frequency of the mode response. p: p value of a Mann Whitney U-test comparing pre- and post-survey distributions. Bias: Noting if the result was significant between pre- and post-survey responses and that the distribution does not appear to have acquiescence bias.

3.a. Responses from Hispanic/Latino(a) Population

	Pre-survey Response					Post-survey Response						
Q.	Mode	Med.	σ	f	Skew	Mode	Med.	σ	f	Skew	p	Bias
1	4	4	1.14	0.48	-1.23	5	5	0.80	0.65	-2.06	0.004	Yes
2	1	2	1.19	0.13	0.45	1	1	1.41	0.54	1.32	0.314	
3	5	5	0.67	0.83	-3.27	5	5	0.32	0.88	-2.48	0.526	
4	4	4	1.05	0.39	-0.59	5	5	0.90	0.55	-1.63	0.043	Yes
5	5	4	0.88	0.35	-0.59	5	4.5	0.72	0.00	-0.68	0.288	
6	4	4	0.92	0.43	-0.68	4	4	1.03	0.41	-1.24	0.032	Yes
7	**4**	**4**	**0.85**	**0.39**	**-0.72**	**3**	**3**	**1.24**	**0.35**	**-0.25**	**0.008**	**No**
8	**2**	**3**	**1.41**	**0.13**	**-0.12**	**1**	**2**	**1.31**	**0.29**	**0.50**	**0.041**	**No**
9	4	4	1.02	0.43	-1.14	5	5	0.71	0.58	-1.63	0.022	Yes
10	**4**	**4**	**0.99**	**0.43**	**-0.87**	**4**	**4**	**0.54**	**0.56**	**-0.08**	**0.008**	**No**
11	4	4	1.03	0.57	-1.47	4	4	0.88	0.47	-1.90	0.034	Yes
12	3	3	1.14	0.48	-0.18	1	2.5	1.31	0.00	0.47	0.095	No

3.b. Responses from non-Hispanic/Latino(a) Population

	Pre-survey Response					Post-survey Response						
Q.	Mode	Med.	σ	f	Skew	Mode	Med.	σ	f	Skew	p	Bias
1	4	4	0.90	0.50	-1.12	4	4	0.97	0.41	-0.81	0.418	
2	2	2	1.38	0.29	0.54	2	2	1.01	0.35	0.33	0.453	
3	5	5	0.82	0.92	-4.50	5	5	1.01	0.79	-2.44	0.441	
4	4	4	0.82	0.42	-0.92	5	4	1.09	0.38	-1.45	0.818	
5	4	4	0.78	0.48	-1.02	5	4	1.03	0.32	-1.32	0.912	
6	4	4	1.03	0.50	-0.84	4	4	0.95	0.50	-1.10	0.322	
7	**3**	**4**	**0.84**	**0.29**	**0.08**	**2**	**3**	**1.37**	**0.18**	**0.08**	**0.004**	**No**
8	4	3	1.29	0.21	-0.46	4	3	1.27	0.16	-0.17	0.674	
9	5	4	1.00	0.33	-1.26	5	5	0.70	0.53	-1.46	0.226	
10	4	4	0.68	0.54	-0.05	4	4	0.82	0.50	-1.91	0.174	
11	4	4	1.01	0.42	-1.02	5	4	1.00	0.35	-0.74	0.631	
12	3	3	1.27	0.38	0.34	5	3	1.38	0.21	-0.12	0.561	

A figure comparing the Question 7 responses of the two populations is given in Figure 3. The responses are strikingly different. For Hispanic/Latino(a)s, the pre-survey response is uniform with a neutral skew and low frequency of any response. It shifts to the positive-end of the Likert scale but maintains a neutral skew—so it may not be due to bias. In contrast, the non-Hispanic/Latino(a) population gave a response that may be construed as acquiescence bias, with a high frequency and low skew that cools to a uniformly distributed, neutral skew in the post-survey responses. This suggests that Hispanics/Latino(a)s found the required videos sufficient, whereas the general population did not. Responses to Questions 13 and 14 from individuals identifying as Hispanic/Latino(a) that may explain this pattern are given below.

- Accessibility of class material- recorded lectures are very useful in allowing for balance in work/life if either of these take precedence at any particular time during the instruction period.
- The accessibility of the lectures and the ability to rewatch them is much more effective than taking notes in an in person class and studying those notes.
- … I was able to review lectures on my own free time. This was my most successful resource when studying.
- The flexibility of having lectures premade allowed for me to watch them when I had free time.

Question-embedded videos [29], recorded lectures [30] and online textbooks augmented with videos [31] improve academic performance over traditional resources such as physical textbooks. It is curious that the Hispanic/Latino(a) population found videos to be more sufficient than the general population. A white paper by *Excelencia in Education* found that Hispanics/Latino(a)s work more than any other demographic, sometimes full-time, while pursuing a college or university degree [2]. Speculating, perhaps the general population had more time to find third-party resources than Hispanic/Latino(a)s. Students with high workload may have little time to study additional resources beyond what is provided by the instructor, such as reading the textbook or finding their own study materials.

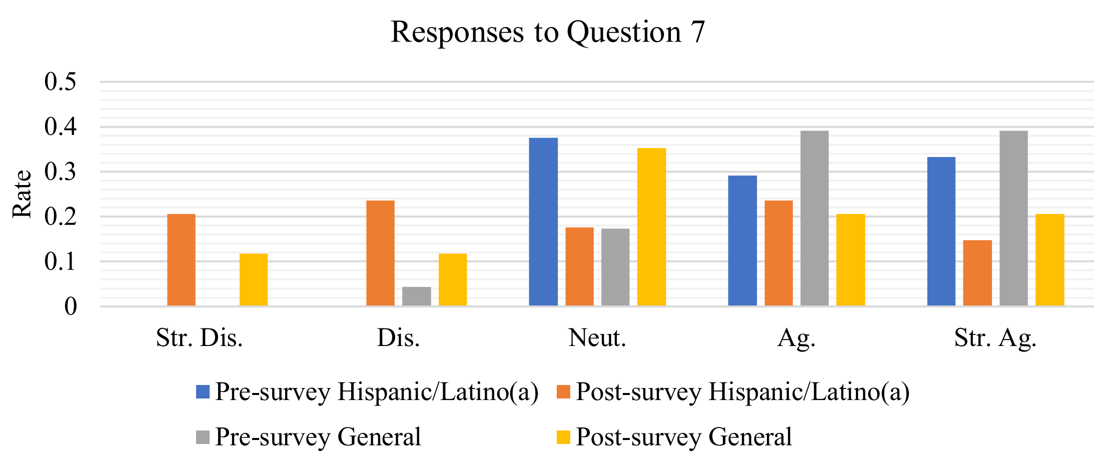
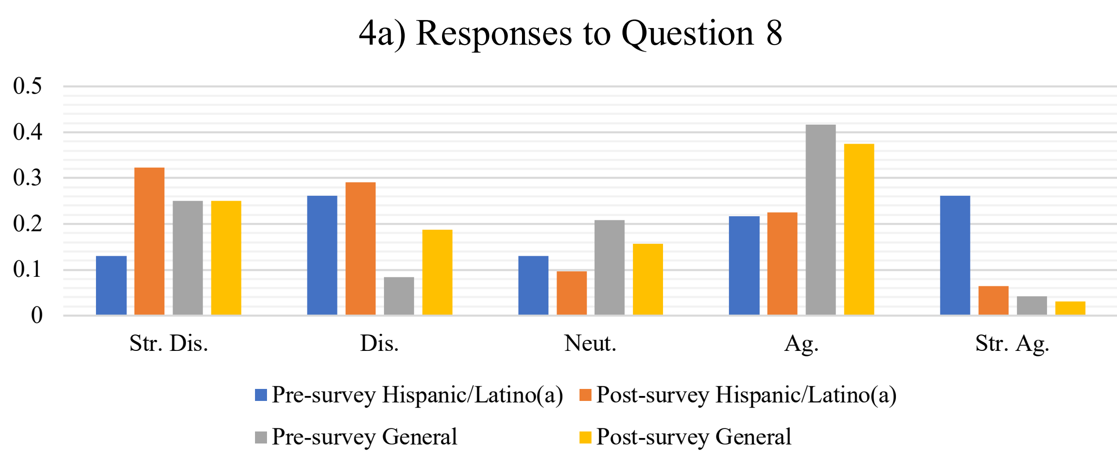


Figure 3: Comparing Hispanic/Latino(a) responses to a general population about sufficiency of materials provided by the instructor in a flipped classroom model.

Figures comparing the two significant findings for the Hispanic/Latino(a) population are given in Figure 4. Regarding Question 8, pre-survey responses were candid. The distribution was uniform with a neutral skew. In the post-survey, opinion shifted to the negative end of the scale, with a positive skew. People in the Hispanic/Latino(a) population were less likely to agree with the concept that it was hard to pay attention in lecture. The general population may have had the same distribution shift, but it was not statistically significant. Regarding Question 10, Hispanics/Latino(a)s gave answers tending positive with a negative skew that became more positive and more negatively skewed in the post-survey. This may indicate that the structure of the class enabled Hispanics/Latino(a)s to better identify prerequisite topics during in-class activities. Speculation on the response to Question 7 and 10, may indicate that the population that watched the assigned videos had an easier time on the activities than the population who may have conflated third party study resources and information with the day's activities.



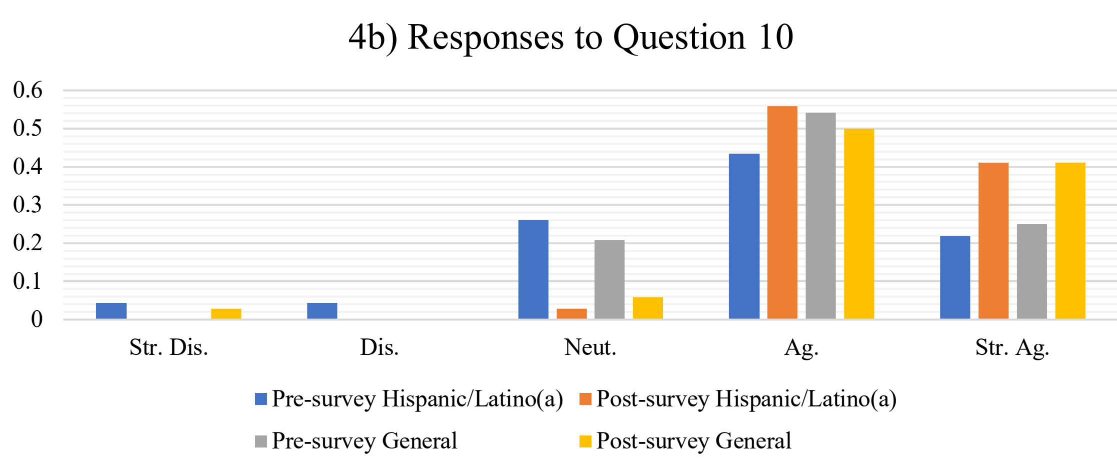


Figure 4: Comparing Hispanic/Latino(a) responses to a general population about a) engagement in lecture activities and b) ability to identify concepts important to the task at hand. For these two sub-figures, only the Hispanic/Latino(a) responses are statistically significant.

IV.A.1 General Analysis of Teaching Styles

In the following we compare the effectiveness of different flipped classroom variations. Instructor A/B and Instructor C used different schemes for generating groups and classes can be different in nature. Some courses may be better suited to time-boxed, hour-long, and graded active learning activities than others. Analysis is limited to sections with at least 10 responses in pre- and post-survey results, and limited to Questions 7, 8, and 10—found to be statistically significant in the previous analysis. Some sections had less than ten consenting individuals (see Table 1), and Qualtrics allows individuals to submit incomplete responses. The sample size for each section is small and we are not comfortable presenting the results of a more granular analysis along ethnic/racial response patterns.

Computer Architecture is an applied class that covers assembly language, digital design of a Von Neumann and RISC microprocessor, parallelism, pipelining, prediction, and cache organization. Activities involved coding and design comparing one solution to another based on performance/throughput. Signals and Systems is a foundational mathematical course covering Fourier Series, Fourier and Laplace transforms, and principles of linear and non-linear systems. Activities were application of equations and techniques covered in videos, such as converting a given time series to frequency domain. Artificial Intelligence is an introductory survey of propositional logic, probabilistic decision making, machine learning, and constraint satisfaction algorithms. Activities consisted of hand tracing or designing a system given an algorithm and data set. All courses are required upper-division core courses in Computer Science except for Signals and Systems which is required for Computer Engineering.

Responses to Question 7 are given in Figures 5 through 7. Unlike the previous analysis the responses do not appear to have acquiescence bias. For Computer Architecture, students tended to find the provided materials insufficient in a statistically significant way ($p = 0.003$). Artificial Intelligence and Signals and Systems are episodic; i.e., the day's activities were mostly explained in the pre-lecture video. Computer Architecture activities build on the previous activity. For example, over a few weeks the students learned assembly language instructions, subroutines, the runtime stack, and calling conventions; culminating recursive algorithms in assembly, such as the Towers of Hanoi or Fibonacci. The premise of the flipped classroom is to assign twenty to thirty minutes of new video material for each lecture. The onus of identifying prerequisite content from previous modules, if needed, is placed on the student. It may be that some students needed more content due to the complexity of the day's topic and turned to external resources such as YouTube rather than pour over older material in the LMS. Future work will require analysis of free-response questions to determine the exact cause of this response. Overall, flipped classroom may be somewhat less effective for classes that are sequential and require students to cross-reference material, such as older videos.

Responses to Question 8 were consistent with the responses from the general population in the previous analysis. There is not a significant difference between pre- and post-survey responses. Figure 10 appears to show a difference but is not statistically significant with $\boldsymbol{p} = \mathbf{0.318}$. So too are responses to Question 10 consistent, particularly a distribution of post-survey responses on the positive-end of the spectrum with a negative skew indicating acquiescence bias. Considering the response to Question 7 and Question 10, it is unknown if this is affected by exhaustion of students' long-term memories when attempting to recall prerequisite topics.

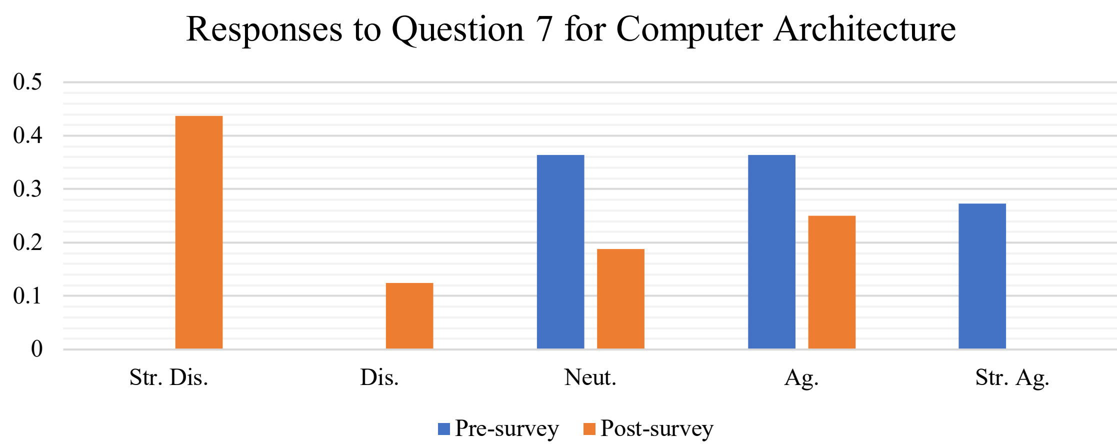


Figure 5: Responses from Computer Architecture students about the sufficiency of materials provided by the instructor in a flipped classroom model. $n = 27$.

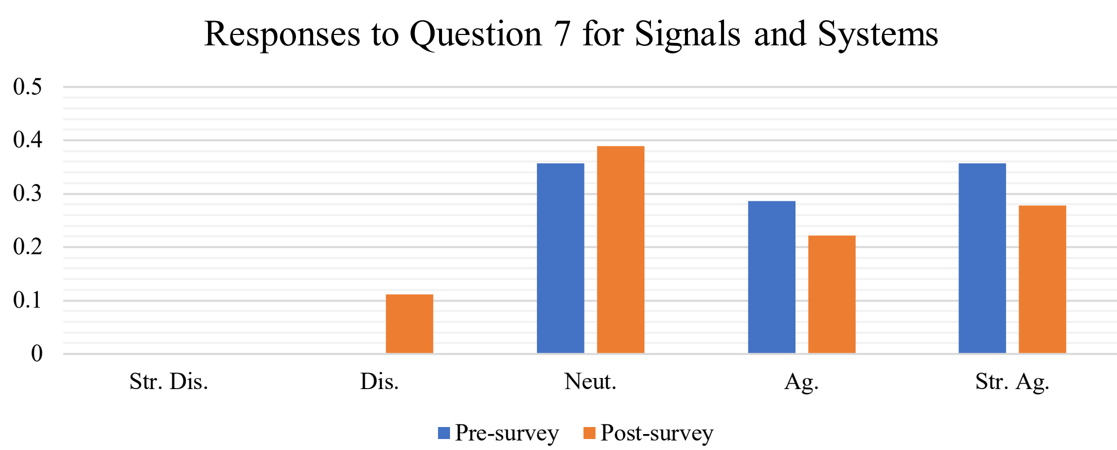


Figure 6: Responses from Signals and Systems students about the sufficiency of materials provided by the flipped classroom model. $n = 32$.

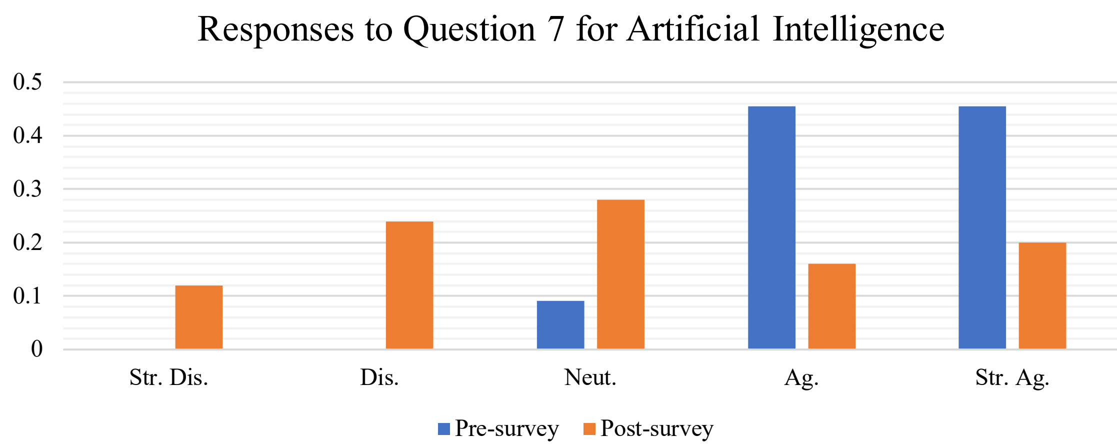


Figure 7: Responses from Artificial Intelligence students about the sufficiency of materials provided by the flipped classroom model. $n = 36$.

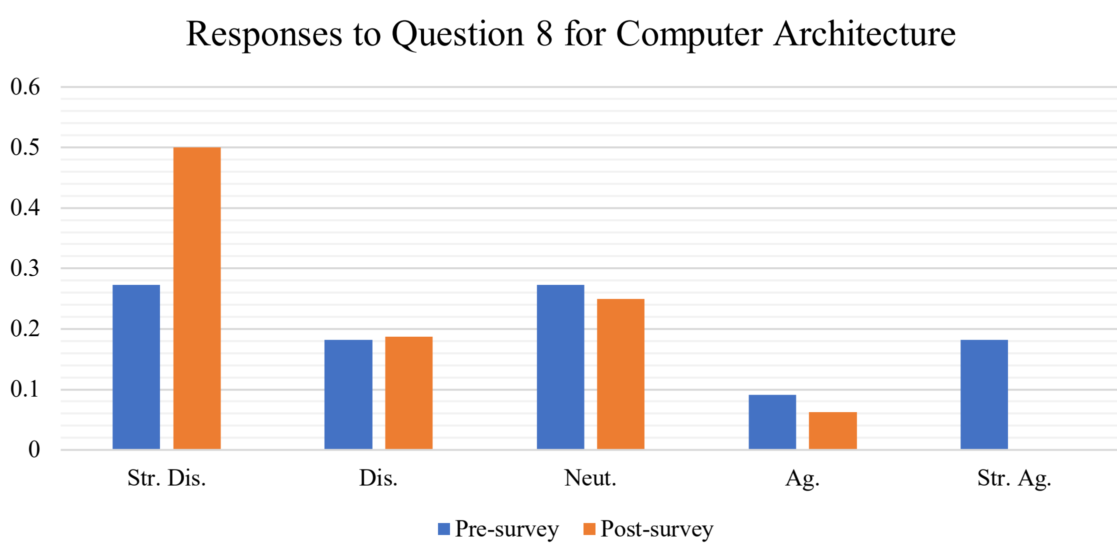


Figure 8: Responses from Computer Architecture students about engagement in lecture activities. $n = 16$.

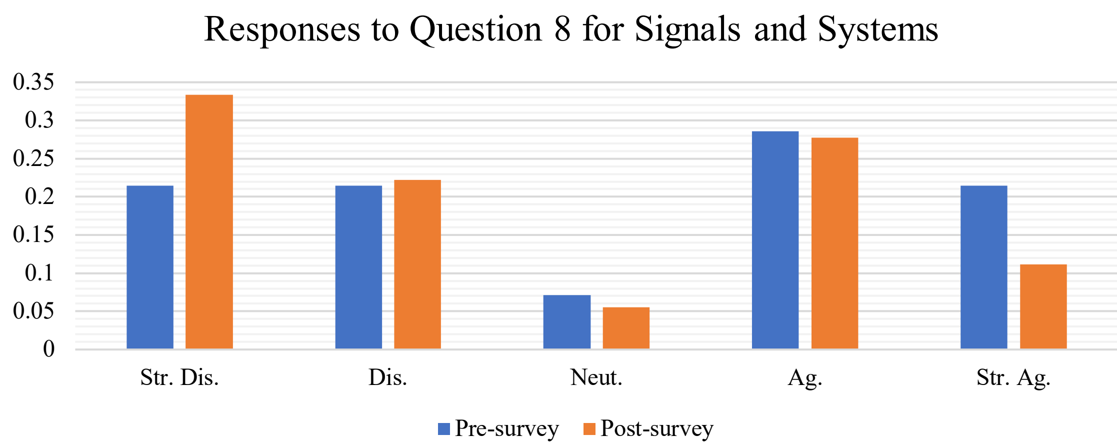


Figure 9: Responses from Signals and Systems students about engagement in lecture activities. $n = 26$.

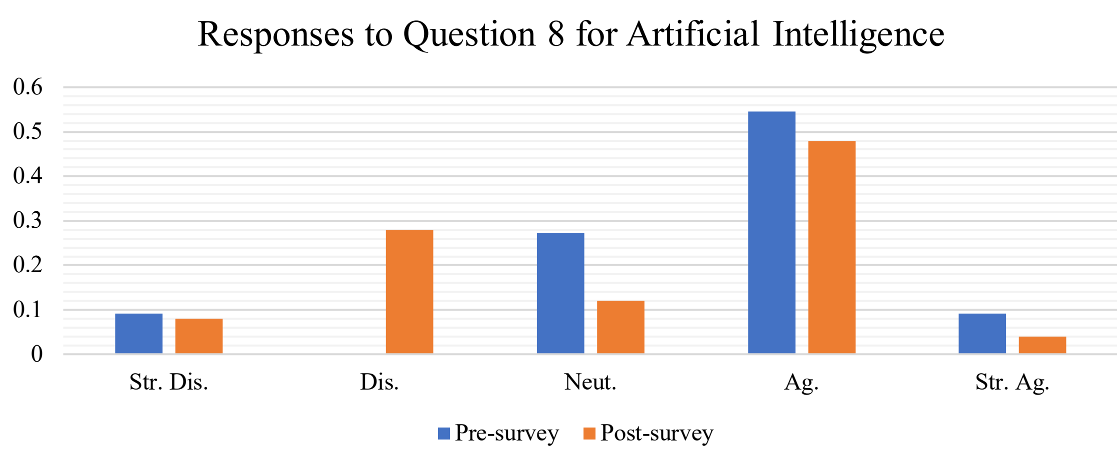


Figure 10: Responses from Artificial Intelligence students about engagement in lecture activities. $n = 23$.

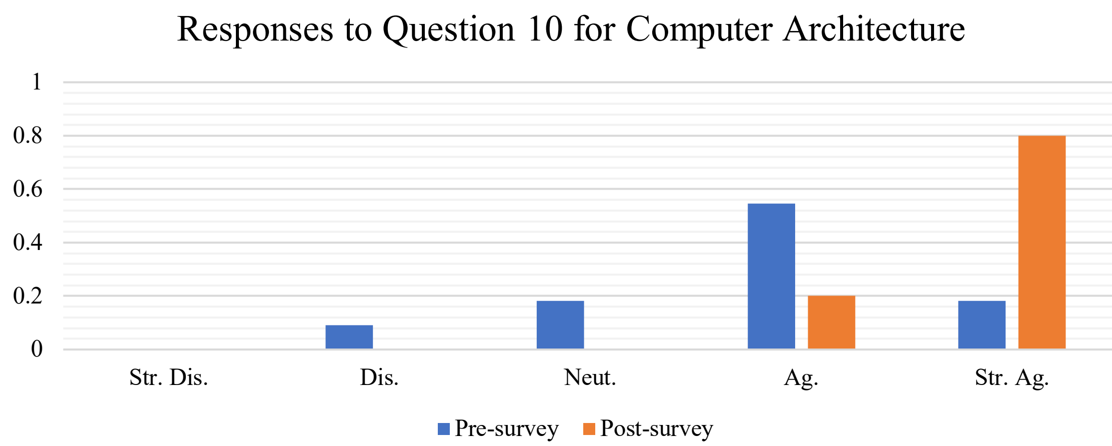


Figure 11: Responses from Computer Architecture students about ability to identify important concepts to the task at hand. $n = 27$.

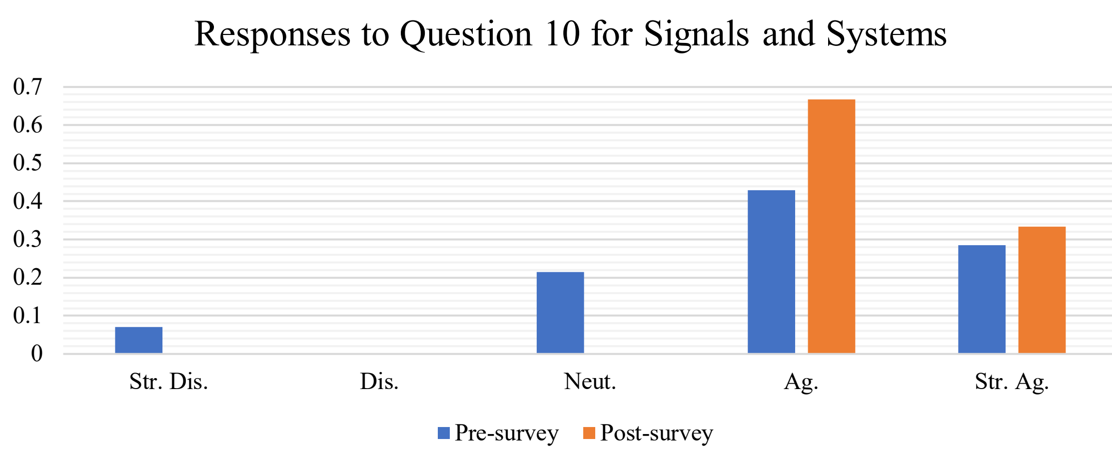


Figure 12: Responses from Signals and Systems students about ability to identify important concepts to the task at hand. $n = 32$.

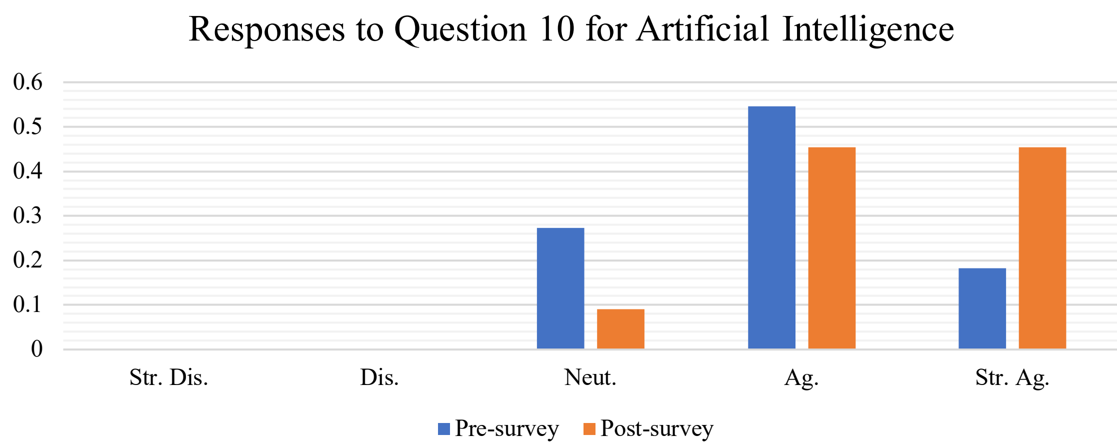


Figure 13: Responses from Artificial Intelligence students about ability to identify important concepts to the task at hand. $n = 36$.

IV.B. Lessons Learned

General lessons learned follow four major themes of assessment, flexibility, resistance to change, and inequalities.

- **Assessment and evaluation:** With FC, assessment and evaluation need to be adapted to the new format, and lecturers need to find ways to measure student learning that are effective and appropriate for the flipped model.
- **Flexibility and adaptability:** FC can be flexible and adaptable to meet the needs of different lecturers and students. The key to the successful flip classroom implementation is the willingness to experiment and make changes to the model as needed to ensure that it works effectively.
- **Resistance to change:** Some lecturers and students may resist the change to the flipped classroom model and prefer the traditional classroom format. It is essential to address these concerns and provide support for the transition.
- **Inequities:** The flipped classroom model may present challenges for students who lack access to technology, reliable internet, or quiet study spaces, potentially exacerbating existing inequalities.
- **Episodic vs. sequential classes:** Section-based analysis reveals that students taking Computer Architecture found assigned module videos to be insufficient. The difficulty of the class was such that students may have had to cross-reference older videos to appreciate newly assigned video content. This may violate some principles of FC, which asserts that students should only watch twenty to thirty minutes of video per class.

Relating to assessment, Instructor A encountered cheating and unauthorized collaboration in synchronized online FC sessions. To address this concern in Spring 2022, the instructor created procedurally generated assignments where numbers and parameters of the assignment would change based on a seed given to a pseudo-random number generator. Students were asked to input their student ID number as the seed to the random number generator, so their worksheet could be reproduced for grading purposes. The prompts were created from scratch in HTML and JavaScript. While this reduced unauthorized collaboration, the amount of time required to implement procedurally generated assignments was a huge time investment—considering that FC already requires more time investment from the instructor to curate videos. Instructor A found that it was not worth the effort to implement this scheme to prevent the handful of individuals who may be cheating on the assignments.

Relating to resistance to change, early on in the study, it was noted that high achieving groups would attempt to segment the work. For example, one person would do the odd questions, and another would do the even ones. The group would not communicate and work separately on the questions. This is not in the spirit of active learning, which requires some sort of social interaction. To discourage this, instructors can structure the assignments as a sequential activity, where one question relies on the result of the previous one. Or, instructors can implement a *pair programming* scheme where one person completes the work while the other audits it.

IV.C. Limitations of the Study

Aside from the stated drawbacks of Likert scales, there are a few limitations to this study. Generally, it is important to examine how the students did in later courses that required prerequisite knowledge from the experimental classroom sections in the study, academic performance or data such as graduation rates. Unfortunately, the IRB-exemption obtained to carry out this study required the investigators to anonymize the student data in a way that they could not be recognized. The surveys were totally anonymous.

Most of the data was collected during remote operation of the university during the COVID-19 pandemic. While we set out to study the attitudes of Hispanics/Latino(a)s to FC, it is affected by the nature of an online class as well as any external stress and pressure due to the ongoing COVID-19 pandemic. Thirty-two of the 123 (26.01%) samples in the study are from face-to-face sections. We are cautious about comparing face-to-face and online sections due to the disproportionate representation of online samples. It will be a focus of future work.

V. Conclusion

Non-traditional students, many of whom identify as Hispanic/Latino(a), are subject to barriers in pursuit of their postsecondary education. One such barrier is their workload that is often greater than that of other demographics. Non-traditional students work part- to full-time and are not able to dedicate themselves to study outside of class. Academia must accommodate the unique context of these individuals. Otherwise, we introduce institutional inequities that prevent upward mobility of otherwise disadvantaged populations. We collected data over three years, from one hundred students, mostly during the COVID-19 pandemic, and from online course sections to determine if Hispanics/Latino(a)s had a positive attitude toward the flipped classroom model (FC). FC requires students to watch videos in their own time. This is an accessible study medium for individuals whose free time is interrupted by work. Yet, attitudes of Hispanics/Latino(a)s toward FC are mixed in literature, with some work claiming that Hispanics/Latino(a)s do not prefer dialogic environments. Our findings somewhat contradict literature in that Hispanics/Latino(a)s found FC more engaging, and that they did not feel the need to supplement their study media with third party resources. We have described our instructional strategy in great detail so that others can reproduce it. More work is needed to study attitudes for face-to-face classes, but it appears that our model is at least somewhat effective at engaging groups of minority students who, according to literature, may not prefer peer activities.

VI. Acknowledgement

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