Improving the online flipped classroom experience and student performance via adaptive learning

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I. Background

Teaching techniques based on "active learning" improve student learning both in the cognitive and affective domains. One such modality of "active learning" is the flipped classroom. However, a challenge for the flipped classroom has been inadequate preparation before coming to class. Typically, students learn foundational content independently before class using "one-size-fits-all" resources such as prerecorded videos and textbook readings, irrespective of ability and interest. In this project, we replaced the "one-size-fits-all" pre-class learning with adaptive learning platform (ALP) lessons to improve the students' preparation and engagement in the classroom. Because of instruction moving to an online environment due to COVID, the implementation was in an online class.

II. Goals

The goals of the project are as follows.

1) Compare the effectiveness of online flipped classrooms with and without adaptive learning based on student learning gains of concepts and affective outcomes. These comparisons are made at a granular level on items such as gender, race, Pell grant status, and transfer status while controlling for pre-requisite GPA.

2) Disseminate and assess the impact of the study's findings and resulting best practices via open education resources, including social media, conference presentations, and faculty workshops.

III. Research Design

We compare two groups - online flipped classroom without adaptive learning (control group) to online flipped classroom without adaptive learning (experimental group).

For pre-class learning

- In the control group, we implemented resources of video lectures, textbook content, and learning tools of limited-attempt self-assessment quizzes (LASAQs).
- In the experimental group, for pre-class learning, we implemented ALP lessons which included resources of video lectures, textbook content, and quizzes.

For the in-class part, both groups used audience response system quizzes, minilectures, and targeted synchronous class exercises in breakout groups. For the post-class part, in both groups, problem sets and programming projects were assigned for higher-order learning.

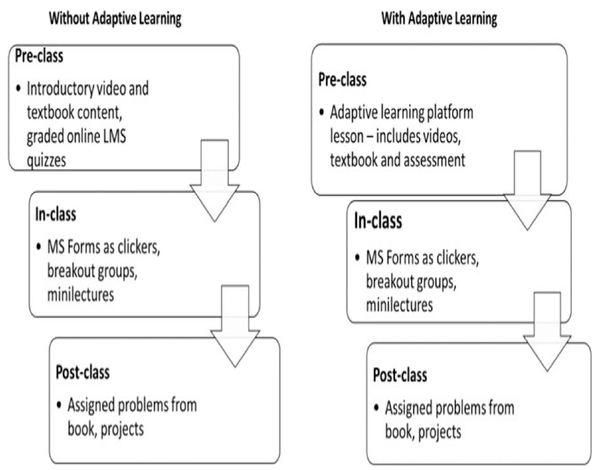
To perform the comparisons between the flipped online course, with and without adaptive learning, we used

1) Concept inventory test

2) Classroom environment survey

3) Flipped mode evaluation survey

The data was collected at the University of South Florida. The data was independently analyzed and reported by evaluators at the University of Pittsburgh.



IV. Results/Evaluation

Concept Inventory Test (Cognitive Domain)

The concept inventory average scores showed a slight, nonsignificant increase when adaptive learning was used, with d=0.14. The Pell grant recipients experienced the most significant positive effect with adaptive learning, with d=0.30 (Table 1). This effect suggests that Pell grant recipients may benefit from ALP lessons in the online flipped environment.

Table 1. Concept Question Score (Percentage) Comparison Between Without and With Adaptive Learning

Demographic Group	Without Adaptive	With Adaptive	Quade's Test	Cohen's Effect Size	Without Adaptive	With Adaptive
	Adjusted Mean (%)		p	d	Sample Size	
All students	53	55	0.59	0.14	86	78
Female	50	50	0.68	-0.01	10	17
CC Transfer w/ Assoc	53	52	0.84	-0.06	19	21
URM	58	55	0.39	-0.16	22	25
Pell Grant recipient	53	59	0.29	0.30	25	16

Classroom Environment Survey (Affective Domain)

Three of the seven CUCEI dimensions had statistically significant or otherwise noteworthy increases using adaptive learning platform lesons. The innovation dimension was associated with the most significant increase in the use of adaptive software. Two other CUCEI dimensions with substantial increases with the use of ALP lessons were the satisfaction and personalization dimensions. In fact, all seven dimensions increased with the addition of the adaptive lessons to the online flipped classroom, although some increases were minimal. Thus, adaptive lessons may be beneficial for the classroom environment in a flipped online course.

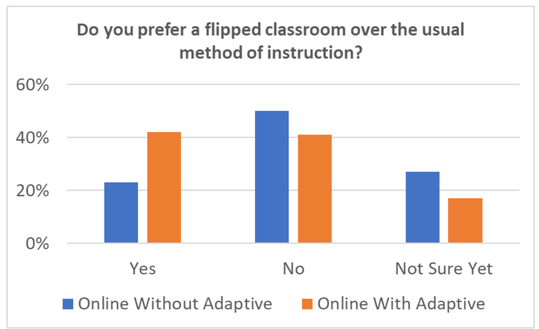
Table 2. CUCEI Results from USF (Scale 1-5, 5 most desirable)

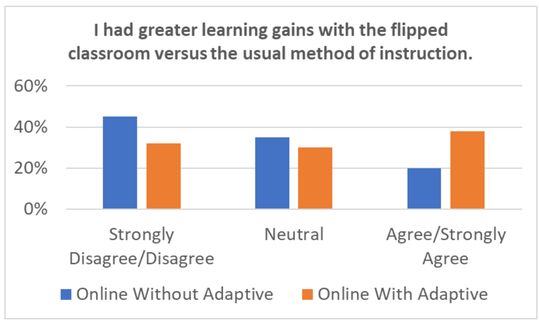
CUCEI Dimension		Without Adaptive	With Adaptive	Unadjusted univariate p	Cohen's Effect Size
		Dimension Mean			
Cohesiveness	Students know & help one another	2.15	2.16	0.91	0.02
Individualization	Treated individually or differentially	2.54	2.59	0.61	0.08
Innovation	Novel class activities or techniques	2.71	3.02	<0.01	0.54
Involvement	Active participation in class	3.16	3.31	0.07	0.29
Personalization	Interaction w/ instructor	3.64	3.95	0.01	0.41
Satisfaction	Enjoyment of classes	3.01	3.40	<0.01	0.42
Task Orientation	Organization of class activities	4.03	4.04	0.92	0.02
	Sample Size	158	207		

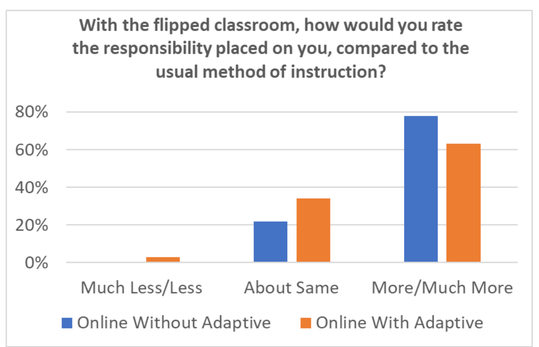
IV. Results/Evaluation (continued)

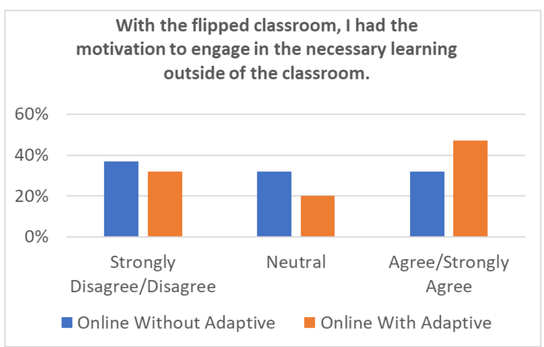
Closed-Ended Responses of Flipped Mode Evaluation Survey (Affective Domain)

Several questions were asked in the flipped classroom survey for both groups. The following tables show the student preferences for the flipped classroom, perceived learning gains, perceived responsibility, and motivation with a direct comparison of the "online without adaptive" versus "online with adaptive learning" environments.









1) More students (42% vs 23%) preferred flipped modality (versus traditional instruction) when adaptive learning lessons were part of the pre-class learning.
2) More students (38% vs 19%) perceived higher learning gains when adaptive learning was used in flipped modality (compared to traditional methods of instruction)
3) Although still high, fewer students (63% vs. 78%) perceived more responsibility with flipped instruction when the adaptive lessons were available versus not.
4) More students (47% vs 32%) were motivated when adaptive learning was introduced in a flipped modality.

V. Conclusions

Flipped instruction in a numerical methods course during the remote instructional period of the COVID pandemic was conducted with and without the use of adaptive learning lessons. This was done to investigate potential differences in student perceptions and performance with and without personalized learning for class preparation in a remote setting.

Regarding the direct assessment of student learning, concept-inventory results were higher when the adaptive lessons were available versus when they were not (d=0.14). The most promising results with direct assessments occurred with Pell grant recipients (d=0.30).

Results using ALP lessons (vs. without) in the flipped online classroom were promising, with an increase in all seven of the CUCEI classroom environment dimensions. The innovation dimension (i.e., novel teaching) increased significantly (d = 0.54). The personalization and satisfaction dimensions had substantial increases also.

A significant decline was observed in the proportion of students who perceived more responsibility with flipped instruction when the adaptive lessons were available versus not. Thus, adaptive lessons may assist the online flipped classroom by virtue of outside-of-class support, individualized instruction, and immediate feedback to students. Equally, based on content analysis of an open-ended question, there was a significant decrease in the proportion of students who experienced load, burden, or stressors in the online flipped classroom when adaptive learning was used versus not, serving to triangulate these results.

VI. Broader Impacts

The best practices developed for teaching the Numerical Methods course in a flipped setting will help faculty willing to use this teaching modality for other STEM courses, online or face-to-face.

The use of adaptive learning addresses several main concerns of flipped modality - the pre-class preparation quality, perceived burden on students, and the classroom environment. The use of adaptive learning addresses one of the 21st century NAE grand challenges of "Advanced Personalized Learning" and addresses differences in aptitude and interests of each student.

A focus of the effort has been on underrepresented minorities, low socioeconomic groups, and non-traditional students, including community college transfers.

VII. References

Clark, R. M., Kaw, A. K., and Braga Gomes, R., "Adaptive learning: Helpful to the flipped classroom in the online environment of COVID?", Computer Applications in Engineering Education, 2022; 30: 517- 531. https://doi.org/10.1002/cae.22470

This material is based upon work supported partially by the National Science Foundation under Grant Nos.2013271 and the USF College of Engineering REU program. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of National Science Foundation.