USING VIRTUAL LAB TO ENHANCE STUDENT LEARNING

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Introduction

Supplemental instruction is defined as an academic support program that aims at increasing student success in high risk courses (Hurley, Jacobs & Gilbert, 2006). Many higher education institutes have in-house tutoring centers where they offer tutoring in writing, math, and various science subjects. Despite this additional support offered by colleges, many students face challenges in their undergraduate courses. This situation exacerbates when students have work and other family commitments outside the classroom. At Georgia Gwinnett College, many of our students juggle between work, family, and school on a daily basis. In order to provide additional support to our Precalculus students, which they can access at their own time and pace, we planned to develop a virtual lab.

The main component of this virtual lab were videos in which we showed step-by-step solutions of the problems that our students usually find hard. Alber (2019) recommends using videos to enhance students' learning. Our plan for using videos was to offer additional examples and explanations on concepts that students find difficult. We found few studies in which researchers implemented some form of virtual lab for their students and found positive result. One such study was by done by Stone-Hernandez, Watson & Miller (2017), in which the investigators added a virtual instructional intervention in their general education mathematics course. Their results showed that the instructional intervention in the form of the virtual meetings helped their non-traditional students. In another study, Tan (2018) incorporated a virtual lab in his Calculus and Linear Algebra classes. He used math programs just as Maple and Matlab to provide his students a visualization of the math concepts. Tan (2018) observed that his students got a better grasp of the concepts through visualization and experimentation provided by these web tools.

With the recent shift of classes to online and hybrid formats, the use of virtual tools have become a necessity. The goal of this project was to provide our students a virtual library of resources that will be available to them at any time outside of class. In this paper, we discuss our first phase of developing and implementing the virtual lab in our Precalculus courses. We compare students' midterm grades between treatment and control groups and present the results of the attitudinal survey. Finally, we outline the difficulties that we encountered and our future steps.

Background

In 2018, the authors became part of the college wide initiative to improve the DFW rates in several courses including Precalculus (Figure 1). This course was chosen as a target math course because it is required for many science majors, and students' inability in passing this course causes a delay in their graduation. In addition, the content covered in Precalculus is essential for many science classes, and students' delay in the completion of this course negatively affect their overall academic progress.

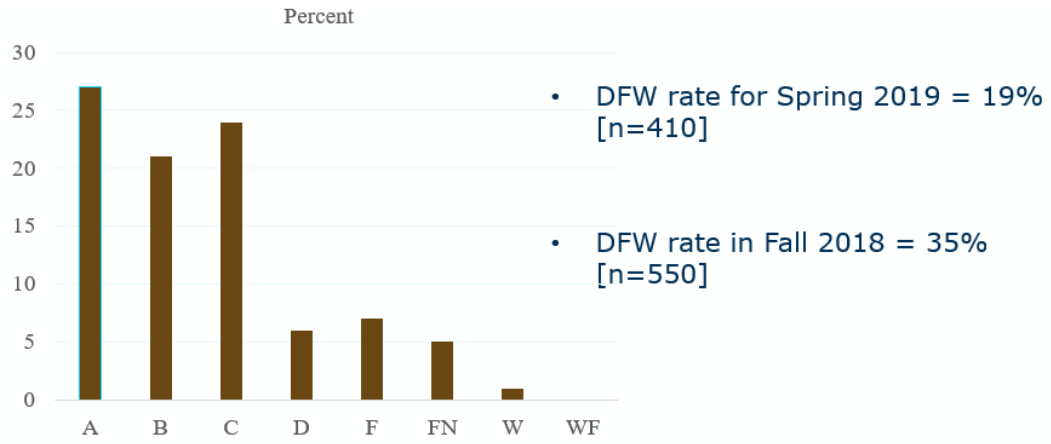

Figure 1: Grade distribution in Precalculus course in Fall 2018 and Spring 2019

One of our initial interventions was to provide supplemental instructions to our students in the form of in-person tutoring. Several faculty members who were teaching one or more precalculus sections participated in this intervention. We targeted students who scored less than 85% on the unit exams and required them to meet with one of the scheduled faculty members for in-person tutoring. Each faculty designated several hours per week for these tutoring sessions, which allowed students to attend a help session on any day of the week.

At the end of the semester, it was clear that those students who fulfilled the requirement benefited from the additional help sessions, but the number of such students was low. Many students reported that outside of class obligations prevented them from attending the supplemental tutoring. We concluded that it is necessary to move the supplemental help to a setting that will be available to students outside of class at the time convenient to them, hence the idea of a virtual lab was developed.

Our vision of a virtual lab was an accessible platform where students can receive supplemental instruction in the form of (1) videos that show step-by-step solutions of problems, (2) practice worksheets that go along with the videos, and (3) a discussion board where students could interact with each other and develop a sense of community. We planned to record videos on the concepts and problems in which students struggle the most. All three of us collaborated and came up with a set of problems targeting the harder to understand concepts. Then, each one of us recorded our own videos in which we solved those problems. For video recordings, we used a program called Explain Everything. In

our second phase of planning, we planned to make the videos more interactive by creating worksheets that students would complete while watching the videos. We also planned on adding discussion threads around those concepts and allow students to interact with each other. Our second phase of planning got delayed in Spring 2020 when we had to switch to online teaching.

Virtual Lab Development

In Fall 2019, we started recording some videos and made them available for our precalculus students as supplemental instruction. Even though very few students took advantage of this supplemental instruction, it gave us confidence to continue developing this idea. In Spring 2020, each one of us was assigned two sections of Precalculus. We decided to use one section as a control section and another as a treatment. For the treatment sections, we created videos on carefully chosen problems, and this time, to give students an incentive, we included some of the problems from the videos into our quizzes and exams. For consistency among all treatment sections, all three of us created videos on the same problems and created common quizzes and exams.

In videos, our emphasis was on the problems that were historically difficult for students. We strived to demonstrate steps on how to solve a variety of problems for each topic. The videos did not include any new topics, but were designed to supplement what was taught in class. The videos were uploaded on our course pages in our learning management system, and were made available to students for the rest of the semester. We regularly informed and encouraged students to watch videos by making in-class and online announcements. Students were not required to watch these videos, but those who did, found them very helpful in understanding the concepts. Some students watched these videos to catch up on the missed lectures, others used them as a review while completing their homework and studying for quizzes and exams.

Results and Findings

We tracked which students were watching the videos by reviewing the completion summary feature of our learning management system. We also asked students the following reflection question at the end of each quiz and test:

"Did you watch the videos posted on D2L? If yes, did they help you in answering the questions on the quiz/test?"

We observed a large disparity among students who watched the videos and those who did not, but found a positive correlation between the quiz results and watching videos. It was apparent that those who watched the videos were getting benefitted from it. An underlying factor for this positive correlation was that the students who watched the videos were generally good students with good study habits, and as a result were doing better than other

students. A more controlled study is needed in order to measure the impact of videos on students' performance. Nevertheless, the videos provided students an additional instructional resource outside the class time where we taught them the same concept with more examples.

The reflection question at the end of the assessments served two purposes, it provided us with statistics of how many students were watching the videos and if the videos were helping the students. It also allowed students to reflect on their decision if they were not taking advantage of these videos. In general, students' responses indicated that they found the videos helpful. Some of the students' responses were:

"Yes, I watched the videos this time and I think they helped a lot"

"Yes, I did, I think they did help me b/c after I completed the hw I had some extra practice, and it was good to listen to the explanation of why and how things happened. So I think it did help me a lot"

"Yes, it did help me because it reminded me how to solve the problems step by step and I helped me study and to be prepared what to expect on the quiz"

"Yes, I did, and yes they did! Very much helpful. Thank you!"

We also conducted a pre- and mid-semester survey to get students' feedback on the quality and usefulness of the videos. A vast majority of the students said that they found the videos very helpful (See Figure 2). About the quality of the videos, the more common responses were: the quality was very good and somewhat good. We also asked students other questions such as whether the videos helped them in getting more engaged in class and the results were positive.

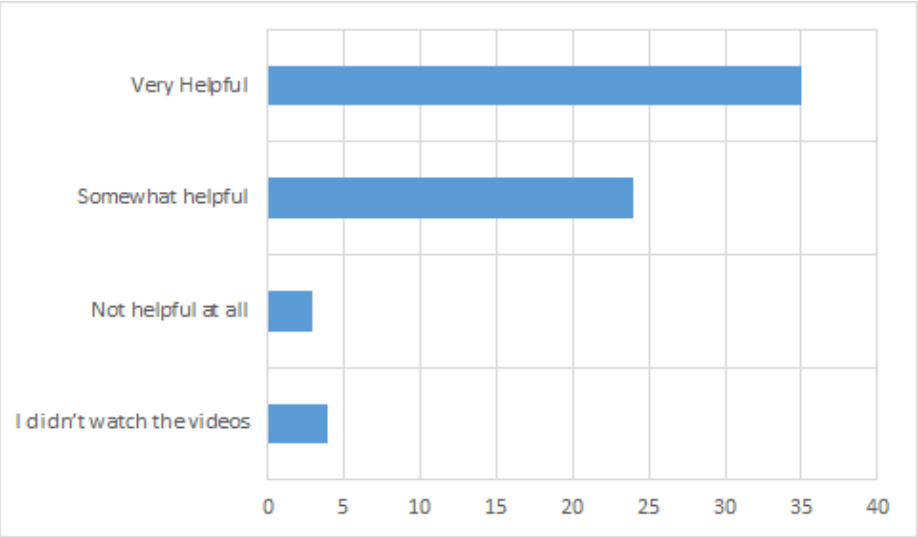

Figure 2: Students' answers to the question "Do you find the provided instructional videos helpful in understanding the concepts presented in class?"

Lastly, we compared students' grades between our treatment and control sections during the mid-semester. We had a total of 3 control and 3 treatment sections. The results were surprising at first as the control section had an overall higher percentage of students who were passing the class as compared to the treatment sections. Digging deeper into the data revealed that the vast disparity among students, who were taking advantage of the supplemental instruction, and those who were not, caused a higher percentage of students in the treatment sections with A and F grades.

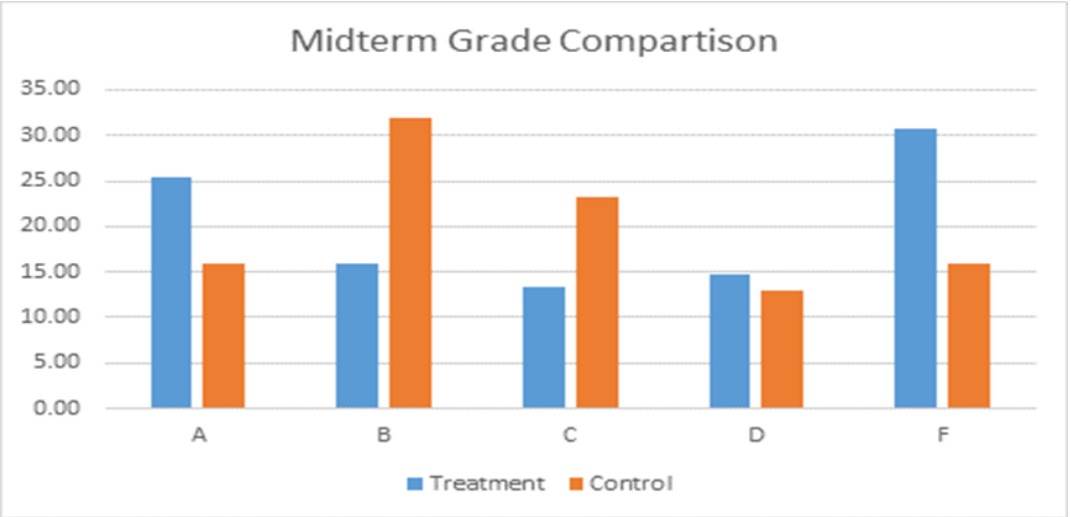

Figure 3: Midterm grade comparison between treatment and control sections

Summary and Next Steps

Precalculus is one of the required math courses for several science and technology majors offered at Georgia Gwinnett College. To help our students and increase the success rate in our Precalculus classes we attempted several interventions, which included the additional tutoring hours outside the class time. After observing that one-hour lectures in class are too rushed for the majority of our students, and that their work schedules do not allow them to attend the additional tutoring, we decided to move supplemental instructions to an online forum.

Our plan for a virtual lab included short lecture videos accompanied by a worksheet and a discussion board. In Spring 2020, each one of us was scheduled to teach two sections of Precalculus classes. We decided to implement the virtual lab in one of the sections and kept the other section as a control. In phase I, the virtual lab only included our videos in which we worked out additional problems mostly on trigonometric concepts that our students historically struggle with. These videos were not counted for a grade so a large number of students did not watch them. We collected and compared the mid semester data between our control and treatment sections, and found a higher percentage of As and Fs in the treatment group as compared to the control group. It was obvious that students who took

advantage of the supplemental instruction had much better grades than the students who did not. We understand that an underlying factor in this positive relationship is that most of the students who watched our videos regularly were generally good students and hence received higher grades on their assessments.

During the implementation of this project we faced a few challenges. Some of these were: 1) There was a learning curve in our implementation of a virtual lab as we were all new to video recording, 2) We could not make all students watch these videos, 3) Students in the treatment and control sections were not homogeneous in terms of students' GPA which skewed the data, and 4) We could not implement the worksheets and the discussion board due to the shift of all classes to the online platform in the middle of the semester.

Our future plans are to continue to improve our videos, create worksheets to make the videos more interactive, and add the discussion threads so students could engage with each other outside the class. To encourage all students to participate in the virtual lab we will assign grades for the worksheets and discussions. To increase the scale of this project we will contact other instructors of Precalculus in our discipline and encourage them to implement the virtual lab in their sections. We will also explore other math tools to add visualization of mathematical concepts in our videos.

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