Active Assessment for Active Learning in the Calculus Sequence: Active Learning Teaching Fellowship Application

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1 Introduction

The Calculus I (MATH 1420) and Calculus II (MATH 1430) single-variable calculus sequence at SHSU has an annual enrollment of over 400 students, and its DFW-rate is among the highest in the university. Nearly all degree plans in the College of Science and Engineering Technology require at least MATH 1420, and most require MATH 1430 as well. Failure to complete the calculus sequence most certainly contributes to the "leaky pipeline" in STEM.

The authors of this proposal frequently teach Calculus I and Calculus II, and have an extensive history of using high-impact practices in these classrooms. We propose a joint fellowship in which we redesign assessment in both MATH 1420 and MATH 1430. In particular this proposal seeks to target attrition rates in the calculus sequence by better aligning the way that we assess our students, which remains heavily focused on traditional assessments such as exams, quizzes and homework problem sets, all completed in a high-stakes environment and assessed individually. This lies in contrast with the way that we teach, which includes student-centered pedagogy in a collaborative and active learning environment.

2 Experience with Active Learning

Here at SHSU several faculty, including the authors, have been employing a variety of active learning techniques in the calculus sequence. This has happened both individually and as part of a larger, coordinated effort among members of our department. Here we detail our particular experiences with active learning in the calculus classroom.

Dr. Taylor Martin: My pedagogical style in the calculus sequence begins with a framework of social constructivism, which says that students learn best when they work collaboratively to create knowledge, drawing on their prior experiences and connecting to prior knowledge [2], [7]. My

classes are structured to use active learning as the primary means of instruction with short lectures supplementing the student-centered environment. Each lesson contains a motivating warm-up exercise, short discussion questions to allow students to reflect back on prior knowledge, and short guided exercises for students to complete and discuss in class. Further, I spend up to 25% of class time facilitating collaborative learning group work. I have written a pedagogical article about this technique [4].

In the 2017 - 2018 academic year, collaborating with Beth Cory, I coordinated a team of faculty teaching MATH 1420 using shared active learning materials. We identified core concepts in the Calculus I curriculum, targeted several student learning outcomes for each core concept, and developed a short unit of active learning classroom material for each concept. These units were comprised of tested material available through sources such as BOALA [1] as well as materials that we developed as a team. We have not finished analyzing the data we collected during this study, but initial findings suggest that students enrolled in an active learning classroom performed better on conceptual common exam questions as compared to students enrolled in traditional classrooms [3].

Dr. Edward Swim: I started teaching calculus as a graduate student in 1999, mostly using a lecture format but sometimes incorporating active learning in the form of worksheets completed in small groups once a week. During a post-doctoral assignment at the United States Military Academy at West Point, I began to develop what has now become my preferred mode for active learning in calculus. This is essentially my personal interpretation of what is called the Thayer Method [6] at USMA, named for an early superintendent at the academy who is known for adapting the style of instruction he observed at the Ecole Polytechnique in Paris to build a comprehensive mathematics program at West Point. Although many people have been trained in what is commonly called the Thayer method and as a result there is a wide variety of viewpoints on its effectiveness (similar to the Moore method of inquiry-based learning), my approach follows the following basic outline:

1. **Require students to read in preparation for discussing new material.** Here I provide students with a short excerpt (1–2 pages) from their textbook or some other source. I evaluate what they recall from this reading using a short quiz at the beginning of class, which serves as a launching point for a discussion or mini-lecture on the topic.
2. **Students solve problems in small groups.** Most of the time, I continue to use short problem sets with small groups of students to reinforce the main theme of the lesson. However, I have started to deliberately create sequences of problems that students to ask deeper questions about the methods they are using and these are often a bit more difficult than the standard examples from their reading.
3. **Students present work at the board.** In my calculus class, students present their work at the board in two different ways. First, I choose a representative from each small group to share their work on a problem at the conclusion of a small group exercise. But on a weekly basis I also require students to present the results of their individual effort on homework.
4. **Students complete applied projects.** Either as individuals or as part of a small group, during most semesters I have had student work both inside and outside of class on projects to reinforce the applications of calculus to their major field of study.

I have had a wide variety of success and failure when implementing this strategy and constantly

work to test new ideas for each component in order to improve my own preparation and facilitate student learning. Student feedback is often positive, and when I get several statements over multiple semesters suggesting that a large subset of the class objects to a particular method I'm using (this happened recently with the CLEAR Calculus lab materials [5]) then I tend to initiate a complete overhaul of what I'm doing.

3 Active Learning Teaching Fellowship Plan

Through the two-year fellowship, we plan to create and implement an assessment portfolio for each of MATH 1420 (Calculus I) and MATH 1430 (Calculus II). During the first year of the fellowship, we will develop this portfolio for MATH 1420, and implement it in the Spring 2020 semester. (We have already arranged for each of us to teach a section of MATH 1420 in Spring 2020.) We will refine the MATH 1420 portfolio and develop and implement the MATH 1430 portfolio in the second fellowship year.

During the development period of the Active Learning Teaching Fellowship, we will conduct a literature review of assessment strategies. We will also compile a thorough list of student learning objectives for Calculus I. We will then design a comprehensive portfolio for assessing mastery of these calculus learning objectives. Our goal will be to accurately assess student learning using a wide variety of assessment strategies which may include group and individual projects, informal student presentations, exams with group and individual portions, techniques from mastery-based assessment, and more. In particular, each learning objective will correspond to multiple items in the assessment portfolio to provide a broad picture about student mastery or proficiency.

The goal of this project is twofold: Primarily, we intend to better align our assessment methods with our teaching methods. When we teach using high-impact practices with a student-centered approach that motivates students to invest in the learning process and engage with the curriculum, but assess in a way that prioritizes individual recall in a high-stakes environment, we suspect that course outcomes don't effectively measure student learning. Secondarily, we hope that our new assessment portfolio will increase student success and academic preparation in courses that traditionally serve as gateway courses to STEM degrees.

4 Assessment

We will assess the impact of our active learning assessment portfolio by comparing student success and student attitude data in our sections with those from other sections of these courses. Typically, there are 8 sections of MATH 1420 and 4 sections of MATH 1430 offered each semester. Instructors teach these sections using a variety of pedagogical methods; some are very traditional, and many use some degree of active learning. We believe that these other sections will give us sufficient comparison data to determine the effectiveness of our assessment portfolio. We will design surveys that help us determine whether, and for how long, students successfully meet learning objectives within the curriculum. Additionally, we will ask permission to track students in MATH 1420 who continue on to MATH 1430 and compare course grades as students move from Calculus I to Calculus II.

5 Dissemination

We intend to get IRB approval to collect and use student data in this project. We hope to be able to publish these results (PRIMUS may be a good venue for this work). We would like to present our findings at MAA's MathFest and the SHSU Teaching and Learning Conference.

However, we are most excited about the prospect of disseminating our findings within the department of Mathematics & Statistics here at SHSU. Since several of our colleagues prefer to use active learning teaching methods in the calculus sequence, we hope that we may be able to transform the way calculus is assessed throughout our department.

References

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