Socrates said that all truths are already inherent in the human mind. The Socratic Method involves the teacher guiding the pupil to knowledge by asking penetrating questions that lead out the knowledge from the pupil. Socrates demonstrates this by leading a slave boy " ignorant of geometry" to discover the Pythagorean Theorem in the special case of an isosceles right triangle.

Socrates begins by making the pupil realize that, on one side of the area of a square by doubling its side, is wrong, and that one-and-a-half times the side won't do it either, causing the boy to become puzzled. That state of bewilderment (meso), according to Socrates, is a key step in education: "whereas [the pupil] thought then that he did know it, and answered confidently like someone who knows, and did not think himself in any difficulty, now he actually thinks he is in trouble, he doesn't know and believes above not to know he knows." [1].

The Socratic, or Active Learning Method, was introduced in the Math Department more than 20 years ago for workshops on course outcomes in groups, with the workshop instructor facilitating their discussion - not solving the problems for them, but leading them to actively work through problems on their own.

This method is one of the most effective ways of increasing student performance in STEM [2], and a characteristic of successful Calculus programs [3]. According to the MAA [3], another characteristic of successful programs is continuous experimentation. In this vein, the Math Department is undertaking a method of all Calculus instruction. The goal is to enhance areas of strength and bring about change in key areas, including the effectiveness of placement procedures.

Methods

1. RUReady Tests: In accordance with new university policies, the placement exams which determine a student's entry level in the math program are now administered online. Such exams are crucial, but their form is perfect, and their reliability has decreased markedly since moving online. The strategy is to use the placement exams as a form of "differential placement" of each student, and to caution students about their responsibility to assess their own ability and to consider registering for a lower-level course. We are taking steps to improve placement, including (1) statistical studies to determine which preliminary skills are most crucial, (2) improving advising to correct student placement problems, (3) improving instruction in study skills, and (4) administering an additional diagnostic exam (the RUReady test) on the first day of class.

2. Improvements in Active Learning: While the Math Dept. has been a pioneer in Active Learning techniques at Rutgers, there are many pedagogical and technological innovations that need to be incorporated into our Calculus curriculum to foster learning.

3. RUReady Tests: The RUReady test is an innovative program at Rutgers engages undergraduates in classroom teaching and learning while helping them develop their teaching, leadership, and interpersonal skills. Learning Assistants (LAs) assist in the classroom in several ways, including facilitating discussions and workshops during lectures, leading workshop sessions with a graduate teaching assistant, or independently supplementing study groups or recitations. LAs are an essential component of the MAA's innovative "Team Teaching" program.

4. Three-Tiered Test Banks: To facilitate the construction of exams that test students' mastery of the material at an appropriate and consistent level, we have created three sets of test questions, each set containing approximately the same number of questions, of which only one set will be assigned to each student, depending on his or her performance in the previous course.

5. Drop-Down & Prep Up: Students who fail the RUReady Test three times during the first 2.5 weeks of the semester are automatically placed in an online remediation program on an expedited schedule.

6. PreCalculus to Intermediate Algebra: In spite of this, we expect to continue to have a significant number of students who will not take Calculus with inadequate preparation. These students may often end up withdrawing from the course and never try it, but they are at better prepared in the next semester.

By tackling this problem, we are initiating a new course "540-123 Preparation for Calculus". This is a 2 credit course that tenure the final 8 weeks of the semester and will be available to students as an "drop down" option from Calculus. The course will not be a fast replay of Precalculus. It will be specially tailored to systematically target specific common weaknesses in background (from elementary algebra through PreCalculus) that block success in Calculus.

From the beginning, these sections will be designed with active learning and "flipped classroom" techniques. Students will make use of online video materials to review course techniques, and class time will focus on addressing student difficulties. Since students in this course, who have already stumbled in Calculus, are likely to require additional attention, the course is to be taught in classes of 30 (other than the 79-79 that is typical for Precalculus). Students who switch from Calculus I to Math 123 will receive a W for the Calculus I course.

Learning Center's Study Systems: The RUReady Tests also help us identify a certain segment of population who are specially at-risk of failing our entry-level courses, so that we can set them up with an early intervention program. These are students who either have a marginally passing score in the RUReady test, or are otherwise ineligible for dropping down to a lower course because they already have the lower course on their transcript. This group of students will have the opportunity of signing up for a special Study Studio program offered by the Learning Center that has both math as well as study skills content, while also emphasizing the importance of proper sleep, nutrition and exercise. The LA program will be collaborating with the Academic Coaching program on this and the LAs will work side by side with an academic coach who has particular experience in math. The study groups are currently being set up. There will be 2 LAs for Precalculus and 5 for Calculus.

CAN Calculus BE TAUGHT?

Yes, but not before students are convinced that they do not know it already. (Just ask Socrates!)

The key to improving outcomes and learning experiences in Calculus courses is a multi-pronged approach that begins with making sure the initial conditions are right.

MATH DEPARTMENT'S P2C2 EFFORTS:

1. Accurate placement.
2. RUReady Tests.
4. Active Learning.
5. Learning Assistants.
6. Uniform standards.
8. Extended study support.