

## RETENTION THROUGH REMEDIATION: ENHANCING CALCULUS I SUCCESS

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Engineering students, and STEM majors in general, often enroll in college but do not have the ability to succeed mathematically in Calculus I. If they do not know algebra and precalculus very well, they do not succeed in calculus, and often drop out altogether. The program described is one designed to save those students whose algebra skills are weak, but not too weak to remediate in a summer program.

### **Program Description**

**Mathematics Placement Exam (MPE).** Every student (at Texas A&M University) that enters as a freshman and plans to major in a STEM field or plans to take Engineering Calculus I takes a mathematics placement exam (MPE). The exam has 33 questions and is a solid assessment of problem solving and algebra skills, particularly symbolic manipulation. Students are allowed 90 minutes to take the exam. A sample can be found at <https://mathassessment.tamu.edu/>. Students may take it online as soon as they are admitted to the university, but some do not take it until they attend the new student conference in the summer. The average score is 26 out of 33, which reflects an increase in the last few years. Over 15,000 students have taken the MPE since 2008. The Cronbach's alpha is about .9 for all students who have taken it, which indicates a high degree of internal consistency of scores.

If the raw score is at least 22, the student is automatically admitted to Engineering Calculus I. The cut score was based on statistics that showed that students who made a 22 or higher have a 70% chance of success in Engineering Calculus I. If the student scores 16 to 21, inclusive, he or she qualifies for the Personalized Precalculus Program (PPP). A student with a score less than 16 must take Precalculus or College Algebra. The PPP is a program that provides a framework for other levels of remediation. For example, if the issue is separating pre-algebra from intermediate algebra from precalculus, the same type of remediation can work.

**Personal Study Plan (PSP).** The PSP allows students to study only the concepts and skills in which they are weakest. The students think they already know precalculus, and they do not want to take an entire precalculus course. They are offered the opportunity to participate in an online course, with a cohort of 20 to 25 students, mediated through WebAssign®, through which the PSP is generated. The cohort is assigned to a tutor, and they participate in live tutoring sessions online via Centra, a live web conferencing and online meeting software program. After a student has completed the program, he or she may retake the MPE then or any time after 30 days from the last time they took the MPE.

**Just-in-Time (JIT).** The students who successfully complete the PPP and place into Engineering Calculus I are still considered at risk. They are encouraged to enroll in the JIT program, which is designed to review the algebra skills they will need in the current and following week in the calculus class. The JIT meets face-to-face twice weekly for 90 minutes each time. A course can be considered to be divided into four quarters, demarked by the three regular examinations. Students can participate in the JIT on a quarterly basis. Students who did not sign up for the first quarter because they thought they did not need additional help may still sign up for JIT after the first exam, when they realize help and support is needed. The cost is \$50 per quarter.

**Model Elements.** The program involves more than the MPE, the PSP, and the JIT. Figure 1 shows many of the elements that must be considered and addressed for a successful program. Like a puzzle that must be assembled, the interlocking pieces can be complex. Besides the program components, interactions with university personnel, parents, tutors, and WebAssign® personnel are part of the equation. All the pieces must fit for the program to work. The cost of the program was \$100 per student summer 2011, but will be \$125 beginning summer 2012. The fee allows the program to be maintained.

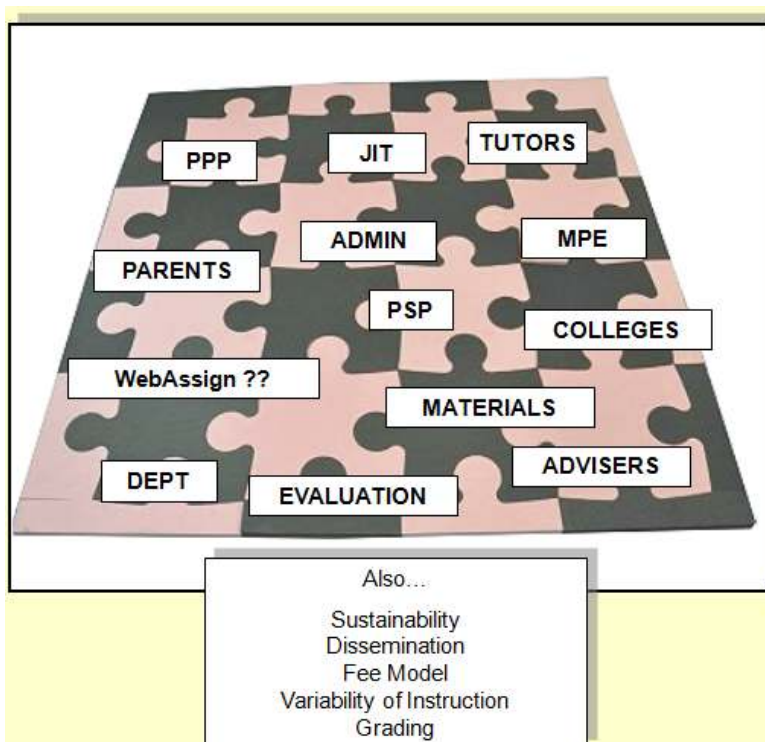


Figure 1.  
*Elements of the PPP Program*

## Materials Development

In the WebAssign® environment there is an online textbook written by mathematics department faculty, 78 short instructional videos, 50 online problem sets, and 4 chapter quizzes. Basically, it is a full precalculus course, but students do not take the entire course. Students who enroll in the PPP take the quizzes in WebAssign® to determine which categories they will be assigned in the PSP. Most of them are assigned three categories to remediate, but some may have only two. They can track their progress by green, yellow, or red bars as they work through the material.

**Year One.** The MPE results were analyzed to find areas of weakness in students who took the MPE over several years. The topics were divided into 4 main categories:

1. Graphs and Functions
2. Factoring & Solving Equations and Inequalities
3. Algebraic Fractions, Exponents, & Radicals
4. Trigonometry

For each category, videos were created. The videos recorded the first year of the program were on topics considered most critical in each of the four categories. Most videos are 5 or 6 minutes long, but some trigonometry videos were a little longer in order to thoroughly explain the material. There is a short instructional section to review material students should have been exposed to in the high school classroom, and then there are several examples. The instruction is designed to address underlying concepts, not just

present rules or theorems. Practice sets and chapter quizzes were created as well. Many problems were available in open source materials in WebAssign®, but gaps were filled with problems authored by project personnel.

**Year Two.** At the beginning the consensus of the program personnel was that too many subcategories would discourage students when they saw the work they needed to do. But after the first year, it was evident that the categories needed to be broken down into smaller subcategories to ensure students are able to sufficiently practice the types of problems they need to master. Once the subcategories were expanded, more videos were created. Problem sets were added to align with the new subcategories and the corresponding videos. Feedback for some questions was started. Because creating feedback for questions is time-extensive, it work in this area will carry forward to next year.

**Year Three.** The plan for the third year is to examine what happened in the PSP in the summer and determine what material students are having the most difficulty mastering. Gaps in student performance will indicate what new videos need to be designed and recorded to support students. If students are taking the quizzes many times before mastery or if many students are not mastering some subcategory topics, additional support materials are needed.

Manuals for students and tutors are planned. There is training for use of the online components, but clear, thorough instructional manuals will be created. Other universities would then be able to more easily use the program if they wish to purchase access for their students. Tutors and students need practice sets that are not **yet** part of the PSP. Tutors will then have problems to use for examples in the online tutoring sessions and problems they could assign students during the tutoring sessions. These sets would help ensure quality control in the tutoring sessions and provide better support for the tutors so they do not have to make up all the example problems to use.

**Student Engagement.** In the first year of the program, students discovered that if they were placed into Precalculus by their advisors or enrolled in the PPP, they could change their schedules and take Engineering Calculus I anyway. This has changed. Currently, students who score below the MPE cut score are blocked from registering for Engineering Calculus I. Students in the PPP still need encouragement to stay engaged and active in the program. The plan to increase student engagement includes sending encouraging emails, which may also include hints for studying calculus and the opportunity to meet with faculty who teach Engineering Calculus I.

## **Program Management**

**PPP Timeline.** There are a lot of tasks that must be completed before the summer PPP program begins. First, the PPP session dates are set and posted on the website (<http://nsfstep.math.tamu.edu>). Tutors must be recruited and selected from the applications submitted. The ideal tutor is one that has navigated both worlds – the high school environment from **which** the students come and the college environment to which

they must transition. Emails are sent to all incoming students reminding them to take the MPE. Letters are mailed to parents so that they are aware of the program and may exert additional pressure on the student to make good decisions about enrolling in the PPP, if necessary. Meetings are set up with advisors and information sheets are provided to them so they have the necessary information to guide students well. Cohorts of students are created, sessions are set up in Centra®, and classes are set up in WebAssign®. Training sessions for new tutors that may be new to the technologies with which they will be teaching are conducted. Students participate in training to learn to navigate the online PSP and working in the Centra® environment.

**Cohorts.** There were eight 6-week sessions in summer 2011, with about 20 students in each cohort. Some sessions had several cohorts meeting with different tutors. Each tutor set up times based on their own availability and times that work best for their students. Doodle polls were utilized to help the tutor set good meeting days and times during the week. Students met with tutors three times per week, for two hours each time, using Centra® conferencing software. Tutors monitored student progress and set target dates for completion of program categories. They also advised students when they should retake the MPE.

### **One Tutor's Experience**

I teach at a community college approximately 90 miles from Texas A&M University. I stay at home or wherever I may be to conduct the tutoring sessions. In summer 2011 I began with about 40 students in two different cohorts. I held a Monday morning session from 10 to noon; then I repeated that session from 3-5 in the afternoon. I held a Wednesday morning session with a repetition in the afternoon. The third session for the week was Friday afternoon with a repetition Saturday morning. I allowed students from either cohort to choose one of each pair of sessions. My attendance ranged from 5 to 15 students at a session. Although I had 40 students that started the course, 33 completed the course and retook the MPE. Eighteen of them earned an A, B, or C in Engineering Calculus I in the fall; nine were not successful in the calculus class, and six did not enroll in calculus in the fall.

**Centra® Sessions.** I had a very social group last summer. During the whiteboard lecture session, there was a chat session going on. They started with greetings like “hi”, “howdy”, “what’s going on?”. We talked about the rain because of the drought we were experiencing and the presence of people from different places. There was a student in Germany; another student participated while in Hawaii. Students from all over Texas and a few places outside Texas participated. I was curious about their engagement in the lesson while they were chatting online. While working on the whiteboard, I would call their names, e.g., “What do I need to do next here, Amanda?” It amazed me that these students could keep track of the chat and what was going on in the lesson. Sometimes the chat included technology issues, like “my mike’s not working” or “fixed my mike”. Sometimes mathematics was discussed, “...something about  $b$  raised to the  $n$  and  $b$  raised

to another n....” or “I got rid of all the negatives first on #3.” I thought students would use the chat when they could not communicate verbally, but they used it all the time.

After discussing the lesson and working examples, I put the students in individual breakout rooms to work a problem I assigned. They were required to work it on the whiteboard so that I could see how they worked the problem. I moved through the breakout rooms to see individual student’s work. Then I brought them back together to make sure everyone understand the problem. Then I put them breakout rooms in groups to collaborate on a more challenging problem. I conducted the tutor session much like any class I might be teaching. Students had assignments between sessions, and the first thing I did when we met again was to answer questions they had over the assignments.

**Social Media.** I thought I was on the cutting edge of technology, somebody who knew the world in which my students lived. The students said, “Ms. Sledge, can we start a Facebook® page?” I agreed that they could, so they did and called it “THE BEST CALC GROUP EVER!” They had a variety of conversations, but they literally helped each other with the homework problems that we had from session to session (see Figures 2 and 3). I am not a big Facebook® user, so I had to remind myself to go into it every couple of days and write “Great job!” or “Way to go!” or “Keep it up!” Of the 33 people who finished my course, 29 chose to be enrolled in the Facebook® group and participate to some degree.

About the fifth week when the students realized they would no longer be meeting weekly, they wanted to get together to meet each other. They discussed a party with e-refreshments on Facebook® or a Skype® party or a Centra® party. The program personnel at Texas A&M decided to have a face-to-face meeting for all the PPP participants so that they could meet each and perhaps continue their collaboration to help each other through Engineering Calculus I.

What I learned from the PPP students changed my own teaching in the fall and spring at the community college. I have always thought that students in the night classes who work during the day could not work together in groups because it was just too difficult for them. But now I encourage them to use Facebook® pages to communicate and help each other with problems. They can use their cell phone cameras to send problems back and forth to one another. In my Calculus II class, we did groups with integration techniques. I had three groups set up Facebook® pages so that they could share the parts of the project they had completed.

Question: if you have  $10y(x+6)^2 + 20y^2(x+6)$  how would you combine the  $(x+6)$ s? can you since one is  $^2$ ?

Like · Comment · Follow Post · June 28, 2011 at 9:17pm

The squared power just means u have 2  $(X+6)$ 's  
June 28, 2011 at 9:22pm · Like

So do you think distribute one to  $10y$  and then after that follow the pattern?  
June 28, 2011 at 9:28pm · Like

yeah so you would have three not two, does it make a difference?  
June 28, 2011 at 9:30pm · Like

try replacing the  $(x+6)$  with an  $a$ . sometimes replacing pieces makes the problem easier to get  $^_^$  just don't forget to put the  $(x+6)$  back in at the end  
June 28, 2011 at 10:26pm · Like · 1

Figure 2.

Facebook@Thread From PPP Cohort

Hey Miranda, maybe this will help?

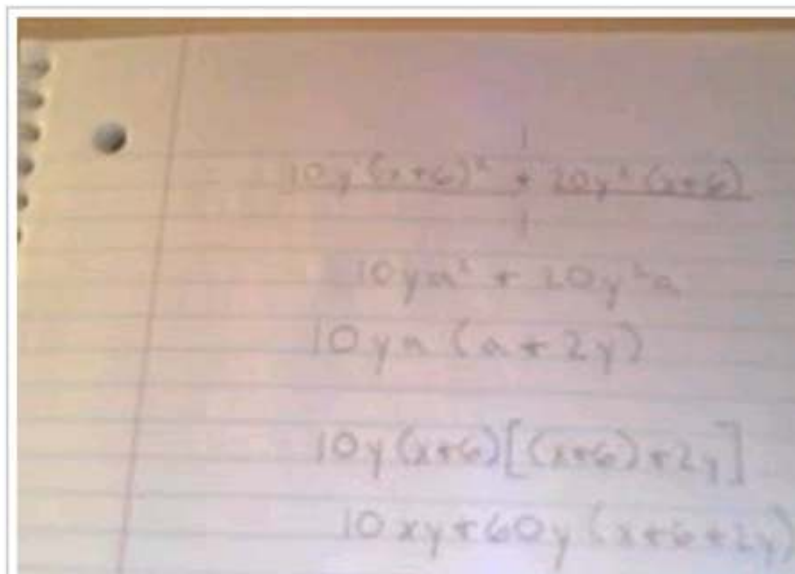

$$\begin{aligned} & 10y(x+6)^2 + 20y^2(x+6) \\ & 10y(x+6)(x+6) + 20y^2(x+6) \\ & 10y(x+6)[(x+6) + 2y] \\ & 10xy + 60y(x+6+2y) \end{aligned}$$

Figure 3.

Facebook Post for PPP Cohort

## **Results and Summary**

Surveys revealed that the tutors were comfortable with the technology after their training sessions. They agreed that the online resources were very beneficial for students in mastering the material. They noted that students often lacked commitment and persistence in the program. Plans for the future include strategies to keep students engaged and on track in the program. Student feedback was very positive, and the most popular component was the online tutoring sessions.

For the first summer (2010), 75 students participated, with a growth to 200 students the second summer of 2011. The expectation is to involve 400 students. Of the students who enrolled in the PPP in summer 2011, 85 students took the exam after the PSP, and the average increase was over 7 points. The program is hosted in WebAssign® and is available for other universities to use (contact [dallen@math.tamu.edu](mailto:dallen@math.tamu.edu) for more information). There is a plan to extend the program to other courses, particularly Business Calculus. In addition, students who scored below 16 on the MPE will be offered the opportunity participate in subsequent summer programs.