Case Study 1: SCALE-UP in Calculus III

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Calculus III is primarily a service course for engineering and science majors and is followed by differential equations, which is the last mathematics course for many of these students. The course is typically divided into five units: vector analysis, analysis of space curves, partial differentiation, multiple integrals, and vector fields. This course has a significant overlap with freshman physics and engineering statics. At Clemson, Calculus III is a four credit hour course and meets for 50 minutes four times per week.

In my opinion, Calculus III should be taught using computation and visualization software such as Maple or MATLAB. Because Clemson has a laptop requirement, I have been able to create an immersive environment in which the software tool Maple is used in all aspects of the course, not just for the occasional demonstration or homework set. A Maple tutorial is provided for each lesson, which contains the main mathematical points along with sample problems worked by hand and with Maple. Review material from freshman calculus and related material from other disciplines is also included. These tutorials serve as reference material for students after the course has been completed. Each lesson also has a set of problems to be solved using Maple, as well as a set of traditional homework problems.

In the following paragraphs, I will outline the components of my SCALE-UP Calculus III course.

The mini-lecture occupies the first 10-30 minutes of the class period, averaging about 20 minutes. I use a Sympodium tablet during the mini-lecture and provide the resulting PDF slideshow to the students after class. I spend part of this time making connections to prior learning, especially to freshman calculus and physics and to engineering statics because research shows the importance of these connections to knowledge retention. For example, I might contrast and compare extreme value problems for functions of a single variable with similar problems for functions of several variables. I spend part of this time talking about mathematical models such as a model for the trajectory of a soccer free kick. I spend part of the time talking about the main mathematical points of the lesson with an emphasis on the conceptual storyline rather than on memorizing procedures. In the end, what I hope to achieve in the mini-lecture is a high level of student engagement and motivation.

I use a learning activity containing problems and discussion questions about 2-3 times per week. Learning activities can be used to review previous material or they can be used to teach (peer instruction) the current material. Students work for 15-25 minutes in teams of three and turn in one paper per team containing their solutions. This is an open resource activity, that is, students can use the text, the tutorials, their teammates or other students at their table, the learning assistants and the instructor. A primary objective which I discuss with the class is that at the end of the activity all team members are up to speed. Depending on class size, I will typically have 1-2 learning assistants in the classroom. They are undergraduates who have taken the course from me in the past. Learning

assistants are provided with the solutions for the learning activity problems along with a set of questions to ask students when they get stuck. The idea is to push students in the right direction through questioning rather than just telling them how to do the problem. This type of instruction is sometimes called guided inquiry. During the learning activity time, my learning assistants and I roam the classroom, watching students work and listening to their discussions. If we see that a team is seriously off track, we jump in with some questions but otherwise we wait for students to ask for help. At the end of the activity, I have a clear picture of what each student is able to do. This is formative assessment. It informs instruction and it provides feedback to students so that they know what they know and what they don't know. The team learning activity solutions are returned at the beginning of the next class period along with comments.

I use a homework activity about 1-2 times per week lasting for 15-25 minutes. Some students work alone but most students work in pairs or threes so the learning community built by the team learning activities seems to carry over. Most students spend this time working on their Maple homework problems. Again, my learning assistants and I roam the classroom, watching students work and listening to their discussions. The learning assistants have the solutions keys which they will use several days later to grade the online submission of the Maple homework. Prior to the fall of 2007, students were required to work a homework problem set by hand in a course journal. The journals were graded in class one day per week by the learning assistants. It was rare to see a student working on their journals in class. For the fall of 2007, the homework journal has been replaced by the online homework system CourseCompass (BlackBoard-based online system used by Pearson Publishing). About 10% of the students work on CourseCompass during the homework activity time.

I use two team based, outside of class projects. For the fall of 2007, I am using a project on modeling the trajectory of a curveball and a project on the placement of cell phone towers. Teams typically meet 2-4 times while working on these projects and turn in a report on their meetings along with their analysis.

I use four hour exams and a final exam for summative assessment. These exams are hybrid with about 80 points for closed-book in class hand written work and about 20 points for outside of class open-book Maple work.

The course grading policy is

- Four hour exams (40%)
- Final exam (20%)
- Two projects (10%)
- Maple Exercises (10%)
- Learning activities (10%)
- CourseCompass Exercises (10%)