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SPARC Project

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Enrollment in introductory CS courses is skyrocketing across the nation. This explosive growth is exposing deep pedagogical flaws that stress our capacity to deliver quality education. The growth is mirrored at George Mason, which is a large (34,000 student) state-funded research university in northern Virginia. In fall 2015, the CS undergraduate enrollment was about 900, double what it was in 2010. Enrollment in CS-1 has more than doubled since 2011 to 484 students in fall 2014. Since most professors are primarily evaluated on their research, they are reluctant to teach courses that impose large time demands, such as CS-1 and CS-2. The combination of rapidly increasing enrollment and focus on research puts enormous stress on our ability to effectively teach first year courses.

The SPARC team at Mason has identified four specific challenges that limit our ability to increase teaching capacity. (1) Students have very diverse backgrounds when they start their computing education. (2) Students learn in different ways. (3) The course evaluations largely focus on syntactic programming skills (declarative knowledge) rather than problem solving skills (procedural knowledge). (4) The same assignments are often used for practice and assessment.

Together, these challenges limit our ability to encourage the kind of collaboration, critical thinking skills, and divergent problem solving abilities that the software industry needs. We characterize this by saying that students are currently taught with an 18th century conveyor belt model, where all students are put in the same boxes and expected to learn the same material at the same rate of speed.

With support from Google's 3X in 3 Years program, a diverse team of George Mason researchers and educators is developing a self-paced learning environment that blends online learning, automated assessment, collaborative practice, and peer-supported learning. Students have practice assignments that are done collaboratively and diverse online resources to learn the material. Students proceed through introductory courses at their own pace, earning “belts” by demonstrating skills and knowledge individually at any time, leading to “black belts” that certify mastery of the courses. Advanced and fast learning students can speed through these courses while less advanced and slower learning students can proceed more slowly.

The student educational experience in the SPARC courses is fundamentally different. We separate practice problems from assessments by defining 10 assessment programming problems per course. Each assessment is supported by online educational materials and eight to 10 practice problems. Students view educational materials (videos, tutorials, recorded lectures, etc.) online, then work practice problems. The practice problems are done collaboratively (supporting diversity of backgrounds and knowledge, and offering multiple chances for the courses to be more inclusive). Practice problems can be worked in or outside of class. Students can work as many practice problems as they wish, and when ready, schedule an individual private assessment in the lab. Students are allowed five attempts to pass each assessment.

This model de-emphasizes competition through collaboration and peer-learning. This directly encourages gender diversity and increases under-represented students. The opportunity to retake assessments multiple times encourages resilient problem solving and encourages students to percieve “failure” as a positive opportunity to learn and improve. We borrow the collaborative and peer-learning approaches from martial arts to support self-paced learning and encourage diversity, but do not copy the competitive aspects.

Allowing students to attempt more or fewer practice problems and to take assessments at any time allows the class to be self-paced, increasing retention and diversity. All practice and assessment results are tracked by software, and the instructors are alerted when students struggle to make it through the material. This triggers an intervention, where instructors and TA work individually with struggling students to identify strategies to improve their performance. This intervention technique helps increase retention of students with limited background, from under-represented populations, with poor study skills, and with educational goals that are different from CS majors.

We expect our “black-belt” model to dramatically increase capacity as well as increase retention, especially among women and under-represented groups. This educational model will free our students from the tyranny of the 3-hour semester course by replacing the conveyor belt with a 21st century model of education. If successful, this project will be transferred to educators world-wide, potentially leading to a revolution in early computing education.

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