Teaching Statement

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Technology should be used to enhance education, not just to cheapen it.

I love everything about teaching. I enjoy organizing the material, lecturing, interacting with students, grading papers, all of it. But my favorite part is when a student is struggling with a problem or a concept, and I can diagnose the difficulty, explain the concept, and see the student get the solution. Seeing that particular light bulb go off, up close and personal, still thrills me. So it may seem counter-intuitive that I have become a strong advocate of using technology to enhance education. However, instead of creating a distance, I've discovered that technology can be used to bring student and teacher closer together. And re-instill a love of learning in both of us! The rest of this document explains this journey, starting with some of my background, my educational role at Mason, and two specific successes I've had with using technology in classes.

My Educational Background

I grew up in an educational desert. My father was the only parent around who graduate from college. Teachers usually taught to the lowest common denominator, and classes were tortuously slow for bright students. Instead of earning respect for learning quickly, I was a target for bullies. Bullying became worse when I skipped fifth grade, and the torture peaked in eighth grade, when the superintendent placed four special-education 15-year olds into a small classroom of 13 year olds. The goal was to let them "graduate grade school" before they quit school. The effect was we learned nothing that year. High school was only marginally better. 40% of my freshman class dropped out, and 10 out of 150 graduates started college. My geometry teacher couldn't do proofs, my chemistry class had no chemicals or even running water, and my senior English class included functionally illiterate students.

By the end of this process, I was poorly educated, but hungry. Starved for knowledge.

My college was what I could afford on my own. It was a small teaching school with no research or graduate programs. Most of the teachers were dedicated teachers, but with limited knowledge and ability. They were there because they couldn't get jobs at better schools. I graduated still hungry.

With luck and high GRE scores, I was accepted into a premier research university for graduate school. My professors were brilliant scientists who ranged from bad to excellent teachers. These two very different university experiences led me to my most enduring principle: *We do not have to sacrifice excellence in teaching to achieve excellence in research*.

I try to exemplify this principle. One of my proudest accomplishments is being the first faculty member in the Volgenau School to be promoted with a rating of Genuine Excellence in both research and teaching. I view research as another form of teaching—where I am both the teacher and the student. My hunger for knowledge has never abated and it has become a passion for teaching. I love to be the teacher I seldom had.

Teaching Principles

This passion has led me for years, and I helped me develop a list of guiding teaching principles.

1. If you don't care about them, they won't care what you say
2. Don't expect them to be students like you were
3. The main correlation with success is frequent detailed feedback—not class size, difficulty, quality of lectures, or the book
4. Respect them as people, even if they don't earn respect from their results

5. Fear is not respect
6. Teach to individuals, but grade anonymously
7. Don't apologize for doing the right thing, but always apologize for mistakes
8. If you don't know the answer, help them find who does
9. If they think you want them to learn, they will learn more

These principles are heavily influenced by my kids, and I owe them for helping me become a better teacher.

My Educational Role at Mason

I came to Mason in 1992 primarily because of the Master's program in Software Engineering (MS-SWE). More broadly, I was attracted to Mason's emphasis on innovation and its entrepreneurial spirit. I have taught 11 different software engineering classes and in 2003 took on the leadership position as Director of the MS-SWE program. I helped create a concentration in Software Engineering within the PhD in Information Technology program (2000), and an undergraduate concentration in Software Engineering within the Applied Computer Science program (2010).

In 2005 I led a major overhaul of Mason's MS-SWE program. The MS-SWE degree was created in 1989 and is one of the oldest and most successful in the nation. The changes were both innovative and fundamental. Both students and the industrial advisory board have been overwhelmingly in favor of this curricular modernization.

My greatest joy in leading the MS-SWE program is seeing the students' end-to-end progress. Dozens of our graduates keep in touch through email and Facebook, including the SWE Alumni @ GMU group on Facebook that I encouraged one of my students to create. My latest innovation is a twitter account that I hope to use to keep in touch with our alum. I attend commencement every year so I can shake each SWE graduate's hand, tell them I'm proud, and wish them luck. My favorite moment was when a 4-year old girl looked up at me with bright tears of joy and pride in her eyes and said "*Do you know what my Mommy did? She **gaduated**!*" I have no idea what that little girl will do in life, but I am 100% certain that someday she too will *gaduate*.

Innovations in Software Engineering Education

I enjoy mentoring students at all levels: undergraduate, MS, and PhD. I was the first in my department to post course materials on my website and one of the earliest adopters of powerpoint in the classroom. I use online discussion boards in every class to expand the conversation. I have created nine courses at GMU, three at each level. Seven had never been taught anywhere and were created without prior models or adequate textbook support. These courses have transformed Mason's software engineering programs. I created and first taught five of the 13 software engineering courses offered in fall 2012, and the current instructors use my materials. I created the syllabus for two others, turning them over to others to create the content and to teach.

My novel approaches to teaching have had significant impacts on software engineering education at Mason and beyond, and are often copied internationally. Software engineering is by nature interdisciplinary, and my courses incorporate elements from computer science, engineering, management and psychology. I eagerly embrace new teaching methods and have invented innovative techniques that continue to be adopted at universities throughout the world.

In my first year at Mason, I redesigned *SWE 637: Software Testing*, introducing a new book and new material. This changed the emphasis from research to practical engineering that directly supports the needs of our MS students and their companies. Dr. Paul Ammann and I re-invented the course again, this time with our own textbook, *Introduction to Software Testing* (Cambridge Press, 2008). The book is the most widely used software testing text in the world. The high quality slides, example assignments, solution manual, and support software make it easy for faculty elsewhere to teach testing. We donate all royalties to the Software Engineering Scholarship Fund at Mason (over $30,000 so far).

I have been invited to teach software testing at numerous places, including the ARTES summer school in Sweden, Samsung electronics in Korea, Rockwell-Collins in Iowa, Skövde University in Sweden, Ewha University in Sweden, the TAROT summer school in Austria, and the Universidad Politécnica de Madrid this January.

I also created a graduate course in designing and building software user interfaces that was unique in looking at software usability as an engineering discipline (*SWE 632: User Interface Design and Development*). This course is now one of the most popular graduate electives in the Volgenau School. It emphasizes collaboration, critical, analytical, and imaginative thinking in an interdisciplinary way. Elements from this course have been copied at universities throughout North America.

In 1999 I created one of the first courses in the nation on engineering high quality Web software applications (*SWE 642: Web Application Design and Development*). The class was a direct response to the specific needs of the Northern Virginia software industry and has technical depth and immediate practicality. 642 is taught every semester, usually by adjuncts with my materials. No textbooks adequately support this class, so I designed it from "whole cloth." The class is innovative in both content and delivery, and it has been copied by dozens of universities. I have taught this material in China, Sweden, and Austria. One of my favorite uses of technology is in-class case studies, where we look at the UIs of web software, then "open up" the backend to study the details of how the software is designed and built.

I have also created and taught three undergraduate courses: *SWE 205 Software Usability Analysis and Design*, *SWE 432 Design and Implementation of Software for the Web*, and *SWE 437 Software Testing and Maintenance*. SWE 432 is one of the most popular electives for CS majors. SWE 205 is the best loved, with an average student evaluation rating of 4.94. I have also created several research-related courses, including *SWE 763 Software Engineering Experimentation*, *IT 821 OO and Architecture-based Testing*, *IT 824 Analysis of Software for Testing*, and *SWE 825 Special Topics in Web-Based Software*.

Using Technology in Teaching

Three years ago I was very dubious of online classes and even discussion boards. I thank two people, Maricel Medina (an MS-SWE student) and Dr. Sharon Caraballo (of the Volgenau School), for convincing me to open mindedly try new approaches. Their encouragement led me to this essay's leading question: "*How can technology be used to improve education, not just cut costs?*" Quality is always my first priority. The following paragraphs present two classroom experiences that were answered the question affirmatively.

SWE 763: Teaching one class at three universities: This class started with another question: *How can one professor teach the same class at three different universities?*

In 2008, I taught *SWE 763: Software Engineering Experimentation* as a traditional, face-to-face class, one day a week for 2.5 hours. The class featured three weeks of lectures about experimentation, nine weeks of in-class discussions of research papers, and two weeks of students presenting the project results. In 2011, a research collaborator asked me if I could spend a semester teaching SWE 763 at Skövde University in Sweden. That was impossible, but the request led me to the above question ...

Teaching a class at multiple, international, universities presented significant problems. Lectures could not be synchronous. Mason regulations prohibited me from being the "instructor of record" at another university while teaching full time at Mason. Would the students be enrolled at GMU or their home institutions? USA students pay tuition directly to universities but tuition is paid by the government in Sweden. Lastly, whose learning management system (LMS) should I use? It is very difficult to enroll students from one university into another university's LMS, and the poor usability of Mason's bulletin board would not support the kind of dynamic interaction needed.

The solution came in several parts. Mason's Provost gave me special permission to be instructor for the classes in Sweden, allowing students to enroll in separate classes at their home universities. The second part was a

happy accident. I got a spam message from a young startup company, *piazza.com*. Their tool is a free discussion board with a modern, social networking style user interface—exactly what I needed!

The course had the same structure as in 2008—three weeks of recorded lectures followed by online discussions. nine weeks of online discussions, and two weeks of student presentations—but entirely online and asynchronous. Once the class was announced, Linköping University (also in Sweden) asked permission for their students to join the class, making us three.

I taught the course in spring 2012 to 20 students, 14 from Mason, five from Linköping, and one from Skövde. I assigned each discussion paper to two students to write summaries and evaluations by Monday evening. Then I used a Swedish custom of assigning a "dissenter" to each paper, who had to disagree with the first two students and post the dissent Tuesday. We spent the rest of the week discussing the papers. Each student also designed an experiment, carried it out, and wrote the results in a conference-style paper. Students selected a project I proposed, or proposed their own ideas. Midway through the semester, they wrote one-page descriptions of their projects, posted them online, and the rest of us offered feedback.

The students quickly melded into one unified class, answering my question affirmatively: *Yes, I could teach the same class at three different universities.* An early impression was that the introductions were more detailed and informative than in a face-to-face class. This foreshadowed the major benefit of the asynchronous format.

The discussions of the research papers were nothing less than outstanding. In 2008 we had a 2.5 hour limit, students often came to class tired, many after a long day at work, and not always prepared to discuss the papers thoroughly. The asynchronous format allowed us to extend the discussions indefinitely, prepare at our convenience, consider other students comments, and add to the discussion anytime. The discussions were both longer and deeper than in the face-to-face class! Unlike in 2008, the 2012 discussions were fascinating and the students taught me as much as I taught them.

The advantages were highlighted during the week of project proposals. In 2008, the students spent five minutes apiece presenting their experimental designs, and then we spent five minutes giving them feedback. In 2012, students posted 10 to 15 minutes worth of material, and received up to four hours' worth of feedback. Some discussions continued for several days.. As a result, their experimental designs were significantly better in 2012. We were truly freed from the "tyranny of the clock"!

The students posted paper drafts on the discussion board, then two classmates read and gave comments. I used PDF's annotation feature to provide comments. At semester's end, students submitted their final papers and presented their results to the class. This was synchronous; students at Mason met in a classroom, and I traveled to Sweden after Mason's finals. I realized then that we had struck gold. In 2008, four of 15 papers (27%) were eventually published. After only six months, five of 20 papers have already been published or accepted for publication (one before the course ended!), one has been submitted for publication, and four are actively being revised for submission. Thus, 25% of the projects have already been published or submitted for publication, and another 25% will be; a potential for half the projects being published!

All students were pleased with the class, and I believe this format can be successfully copied with any discussion class, whether in scientific research or in literature. The discussions and diversity of projects meant the class emphasized divergent thinking, reducing the problem of determining who actually did the work. Moreover, the multi-university format offers several interesting possibilities. If there aren't enough students to support a specialized class, they could join the same class at another university, even on another continent. If a class is taught by someone with unique expertise, students elsewhere could join. This format could scale from 20 to 200 students if professors at other universities participated in the feedback and evaluations. This opens the possibility of what I call "*crowd teaching*," where a diverse team of professors from 5 or 50 universities merge their courses online, all being responsible for part of the content, but each professor being responsible for managing a subset of the students.

SWE 637: Using a flipped classroom: I first heard about "the flipped classroom" in a presentation from the Center for Teaching Excellence. Instead of listening to the professor talk, then doing homework, students in a flipped class listen to recorded lectures at home, then work problems in the classroom.

This semester I flipped my classroom for two weeks in my graduate software testing class. I picked problem-solving material that students often struggle with. I recorded the lectures in 15 minute chunks and posted them online. Students were told to view the lectures before class. In class we worked problems together, then the students started their "homework" and called if they needed help.

The results were quite positive. Five students completed the assignment in class. Much of my time was spent explaining subtle points of the material to students who missed it in the reading and lecture. Other students needed help with some of the basics. It's easy to say "they should already know it," but this format let us fill in holes in their knowledge so they could succeed in this part of the class.

I followed with three questions on our class discussion board: "*Did you view the lectures before class?*", "*Did you feel the flipped classes were useful?*", and "*Do you think you did better on the homework because of the class session?*". All the respondents said yes to all three, and students are asking for more flipping.

The crucial question is whether the flipped model enhanced their l. I compared with the same assignment from the previous two years. The average was 88% in 2010 and 86% in 2011, but 98% in 2012 with the flipped classroom. The lowest score increased from 65% in 2010 and 63% in 2011 to 90% in 2012. Theorizing that a flipped classroom might help struggling students more, I computed the average of the bottom half of each class. These averages went from 75% in 2010 and 74% in 2011 to 94% in 2012!

This experience demonstrates that the flipped model can improve education and also be effective in graduate courses. The flipped model has several advantages: (1) Working problems in a group can help. (2) It's hard to concentrate for an entire class, but students can pause recordings at any time. (3) Flipping lets students go at different speeds, which is a relief to gifted students and a benefit for struggling students. (4) The in-class sessions let professors focus on what each student needs individually, rather than treat all students the same.

What this Award Would Mean to Me

I love engineering, I love computer science, and I love teaching. I love innovating with new topics and new methods of teaching, and I love the diversity that we have at Mason. I believe collaborative learning and divergent thinking are necessary to teaching engineering effectively. A wonderful surprise of these technological innovations is that they allow me to provide **more** individual attention to students. I see that light bulb more often! Using technology allows me to spend more time teaching instead of lecturing.

Ammann and I are working on a second edition of our software testing book. In 2008 we provided powerpoint lectures, which I now think is very 20th century. A 21st century textbook should include complete *recorded lectures*. Instructors should be able to send students to the book website for the lectures, and come to the classroom for clarifications, to work problems, and most importantly, to learn.

Teaching these students at this university is a privilege, made better by the many excellent colleagues I've been fortunate to work with. Of course, any award that recognizes hard work is welcome, especially hard work that is not recognized during promotions and regular evaluations. But I have longer term goals. I want to expand my multi-university course by using crowd-teaching. I hope to take a stronger leadership role in the Volgenau School in teaching excellence in general, and teaching with technology in particular. I want to expand my successes in my own classes, and strongly hope to teach my colleagues the lessons I've learned. **Yes, we can use technology to enhance education, not just to cheapen it.**