

Project Title: **Immersive Software Engineering**  
A proposal in response to the Innovation in Education Awards 2009 request for proposals

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## Executive Summary: Immersive Software Engineering

This project aims to fulfill four goals:

- Develop a new software engineering course on the techniques of project management, requirements, analysis, specification, design, coding, documentation, testing, maintenance and communication.
- Establish a repository of software engineering code that will be reused and expanded in following editions of the course
- Introduce a peer-based framework for improving the oral and written communication skills of Computer Science and Computer Engineering students.
- Foster collaboration among faculty and students in the Computer Science (CS) Department, the English Department, the Pitt Writing Center, and the Pitt Oral Communication Lab.

The proposed course and communication framework address a gap in the education of Computer Science and Computer Engineering students. The course will provide the academic component for capstone experience for senior undergraduates, by purposefully tackling large, team-based, real-world problems, as opposed to toy examples. Additionally, the course will introduce novel material into the CS curriculum, including project management skills, usability testing, customer interviewing, and specification of formal requirements, “soft skills” which will make our graduates more competitive in the global marketplace and less susceptible to off-shoring. Finally, the project introduces a much needed, significant oral communication component into the CS curriculum. Oral communication has been identified as one of the four basic general education skills in the University of Pittsburgh’s undergraduate education program.

The potential impact of the project is multifold. Undergraduate students specializing in software engineering will be the first to benefit, by acquiring new technical and communication skills. CS students in general will benefit from the code repository, which will accelerate the learning process of software design. English majors who train to become Writing and Rhetoric Tutors have an opportunity to improve their interpersonal skills, and a chance to develop as writers, speakers, and educators. English and CS graduate and undergraduate students will mutually benefit through the peer-based framework for improving communication skills. Finally, the emphasis on community-based projects will provide students with an education that integrates research and includes more parallels with what they are likely to see beyond Pitt. These connections will further encourage the collegial, cross-disciplinary, and inter-departmental approach to research and education that Pitt is known for.

An additional benefit of the project is that it requires very little resources. The project integrates existing university resources into a novel, self-evolving collaborative framework.

## Key Personnel

**Project Director:** Dr. Marai is an assistant professor in the Department of Computer Science at the University of Pittsburgh, and founder and director of the Pitt Interdisciplinary Visualization Research Lab. She is also an adjunct assistant professor at Carnegie Mellon University, the Robotics Institute. Her research focus is on applications of computational modeling, visualization, computer graphics, and computer science to other scientific disciplines. Through her lab, Dr. Marai is building a network of colleagues and collaborators across disciplines, across the campus.

Since joining Pitt in 2007, Dr. Marai has taught both undergraduate and graduate courses. She has redeveloped and taught the undergraduate introduction to computer graphics course (CS1566), co-designed the undergraduate game design and development course (CS1666), introduced and taught a graduate course on interdisciplinary modeling and visualization (CS2620). The undergraduate graphics course boasts a 100% retention rate in 2008, and an impressive gallery of project results. In 2008 Dr. Marai was awarded a departmental Teaching Award, based on student feedback and evaluations, for her graduate-level computer graphics course.

Finally, Dr. Marai has extensive mentoring experience. Aside from research advising, her undergraduate course staff includes each year at least one undergraduate teaching assistant. She is also the founder and coordinator of the Pitt Women in Computer Science organization.

**Additional Staff:** One undergraduate Computer Science student will be recruited through the Arts and Sciences Office of Experiential Learning to serve as an undergraduate teaching assistant for the proposed course. Two undergraduate English majors will be recruited through the Pitt Writing Center to serve on an hourly basis as Writing and Rhetoric Tutors for the course.

**Collaborator:** Dr. Geeta Kothari, the Director of the Pitt Writing Center and founder of the Pitt Peer-Tutoring Program, will assist the project director in establishing the framework for improving the oral and written communication skills of Computer Science students (see attached letter of support).

# Immersive Software Engineering

## A. Goals, Motivation, and Innovative Merit

### A1. Goals

This project aims to fulfill four goals:

- Develop a new software engineering course on the techniques of project management, requirements, analysis, specification, design, coding, documentation, testing, maintenance and communication.
- Establish a repository of software engineering code that will be reused and expanded in following editions of the course
- Introduce a peer-based framework for improving the oral and written communication skills of Computer Science and Computer Engineering students
- Foster collaboration among faculty and students in the Computer Science (CS) Department, the English Department, the Pitt Writing Center, and the Pitt Oral Communication Lab.

Essentially, the funding will act as seed money, to jump-start the project, which will be self-sustainable beyond its initial funding period.

### A2. Rationale

Software Engineering is a core field of computer science, dedicated to creating software that is of higher quality, cheaper, maintainable, and quicker to build. While software engineering textbooks are deemed to be “*uniformly amongst the most boring writings in all of human literary output*” <sup>[1]</sup>, the field holds treasures of excitement: for example, software engineers have designed Gmail, Facebook, Twitter, Amazon, and the iPod software. How do we account for, and address, this discrepancy?

A basic observation is that software engineering requires not only technical skills — which can be learned in a theoretical framework, but also “people skills” — which textbooks and typical CS courses do not teach. In the real world, software engineers have to interact with and interview real users — most of whom are non-technical (drivers, dentists, supervisors etc.) — and then deploy their product to the same audience. Software engineers also tend to work on large-scale projects, in large teams, which often include both technical and non-technical personnel. It is this interaction, and the motivation that comes from having a real user and handling a real problem that makes software engineering exciting. <sup>[2]</sup> Therefore, we propose an immersive approach to teaching software engineering, through which students will learn and practice simultaneously specific software engineering methods on a large, real-world project.

Because strong communication skills, and in particular oral communication skills, are paramount to the field, the students will also learn to communicate better by writing regularly, through feedback on every written assignment, by presenting several times in

class, through required consultations with Writing and Rhetoric Tutors — an important component of the proposed project, and through critiques of the presentations by the course staff and the tutors.

We note that CS students at the undergraduate level tend to have far less experience and training in oral communication and speechmaking than they do in writing. As CS faculty, we frequently deal with novice speakers; yet we rarely encounter students with virtually no writing background. Because of their relative inexperience as speakers, many students are uncomfortable and anxious at the mere thought of giving an oral presentation in front of a group of people. This anxiety makes confidence-building through training and peer-tutoring particularly important.

Last, but not least, managing and reusing large, often poorly-documented repositories of software inherited from previous developers is a fact of life in software engineering. In this spirit, we will establish a repository of code to be reused and expanded in following editions of the course. The repository will be beneficial to all software design courses in the CS department.

Pitt CS has two courses that would loosely be classified as “software engineering” in other computer science departments. One is a junior-level course, CS1530, which introduces students to medium-scale program design, small-group programming, and a collection of basic software design concepts. The other course, CS1631, is a higher-level course which emphasizes software design methodology. Both courses are primarily introductory methodology courses necessary in the CS curriculum, yet neither sufficiently prepares the students for the challenges of software development in the real world. The proposed course will complement the current curriculum by providing the academic component for the capstone experience for senior undergraduates in CS and CoE.

### **A3. Innovation**

The main innovations behind the proposed project are two. First, the proposed course will use real-world, community-based projects to introduce novel material into the CS curriculum. Such material includes project management skills, usability testing, customer interviewing, and specification of formal requirements, “soft skills” which will make our graduates more competitive in the global marketplace and less susceptible to off-shoring. Second, the project will introduce a much needed, significant oral communication component into the CS Department, and will jump-start a cross-disciplinary collaborative effort among CS, the English Department, and the Pitt Writing Center.

## **B. Project Description**

The project will essentially entail three stages: design, implementation and evaluation. The design stage will take place in the summer of 2009, and will comprise setting up the peer-based communication framework, developing the course materials, identifying an

interesting class project, setting up the code repository, and recruiting the course staff. The implementation stage will take place in the following academic year, when the course will be taught, the code repository will be instantiated and expanded, and the class-project will be completed. The evaluation stage will run simultaneously with the implementation, and continue for at least one more term after the end of the class.

### **B1. Course and online repository**

In the proposed course, students will identify, design, and implement significant software applications and learn and practice techniques of project management, design, coding, testing, maintenance and communication. Lectures and short assignments will build up to the main project. The project director has test-driven a similar approach in her graduate-level classes, with excellent student feedback.

As useful preparation for the main project, students will conduct mock interviews with the course staff, who will pose as employees of small companies (for example, employees of a small bookstore in Arizona, or the campaign staff of a young politician). Some of the course staff will play technological ignoramuses and even Luddites — the type of partners that computer scientists usually struggle communicating with. There will be several short written assignments in which the students will present the assignment problem and propose solutions. The staff will organize elevator-speech competitions which the students will use to promote their ideas. The class and staff will vote on these ideas to identify the most promising approach. To prepare for these assignments, the students will be required to meet regularly with the Writing and Rhetoric Tutors. The tutors and the course staff will also provide feedback after class assignments and presentations.

For the main project, the students would have to interview actual clients and then deploy their product to the same audience. Quick prototyping and iterative user-feedback — both essential aspects the modern spiral model for software engineering — will be inherently necessary. The students will have to deal with problems in integrating large components, especially components that are themselves evolving. The best way to tackle this is to have smaller groups work on different parts of the same system, thereby (inadvertently) creating trouble for one another and negotiating solutions. This will force students to collaborate and be team-players if they want to succeed, skills that are crucial and often neglected in the CS curriculum.

A written and oral presentation at the end of the class-project will be required. The final project results will also be demonstrated during recruiting events organized by the CS department (e.g., Pitt CS Day, organized each March and attended by local high-school students).

The online repository of code and tools is a critical component of this project. In general, 70% to 80% of any modern software application is graphical user interface code. Such code is notoriously tedious to write from scratch, but trivially easy to emulate from existing examples. The project online repository will be initialized with existing code and tools collected from the director's previously taught graphics courses, allowing the students to build quick, functional prototypes from the provided examples. Code and

tools generated by the students throughout the class will be added to the repository each year.

## **B2. Writing and rhetoric tutors**

The Pitt Writing Center runs a Peer-Tutoring Program which is sponsored by the School of Arts and Sciences. The Writing Tutors are English majors who take a Center seminar in the theory and practice of teaching writing. The director of the Writing Center will help recruit two experienced Writing Tutors to participate in the proposed project. The project director and the Writing Center director will negotiate additional tutor training with the Oral Communication Lab. The tutors will receive additional training in coaching public speaking through the Lab in the fall of 2009 and become Writing and Rhetoric Tutors. The project director will hire these Writing and Rhetoric Tutors on an hourly basis to provide customized help for improving the students' writing and oral presentation skills.

## **C. Significance and Broader Impact**

The potential impact of the project is multifold. Undergraduate students specializing in software engineering will be the first to benefit, by acquiring new technical and communication skills, and in general by being better prepared for the type of problems they are likely to see beyond Pitt. CS students in general will benefit from the code repository, which will accelerate the learning process of software design. Graduate students and undergraduates enrolled in other CS courses or involved in research are likely to benefit from the communication framework we will develop.

English majors who train to become Writing and Rhetoric Tutors have an opportunity to improve their interpersonal skills, gain editing experience, and a chance to develop as writers, speakers, and educators. On the other hand, the Computer Science majors would achieve competence in writing and oral presentations through active, individually and assignment-tailored dialogue with their peers in the English department. Such a collaborative initiative fits well with the School of Arts and Sciences mission.

Finally, the emphasis on community-based projects will further encourage the collegial, cross-disciplinary, and inter-departmental approach to research and education that Pitt is known for. Perhaps the most significant impact will not be in the curriculum enhancement or in the specific-applications resulting from this project, but in a better understanding of what makes large community-based projects succeed or fail, and in the new, articulated, team-trained computer scientists that will emerge from Pitt.

## **D. Sustainability**

One of the fundamental benefits of this project is that it requires very little resources, aside from the project director's commitment in terms of time and energy. The hardware and software infrastructure will come from the Computer Science department and the project director's lab, which include state of the art computing resources.

The peer-based tutoring framework integrates existing university resources. Past this project, further financial support for course-related peer-tutoring will be secured through departmental resources, respectively through individual faculty grants for research-related tutoring.

## **E. Evaluation**

Multiple metrics will be used to evaluate the success of the program:

- The number of students enrolled in the proposed course, the enrollment retention rate over the semester, tracking job-placement after graduation, as well as OMET feedback will be relatively simple evaluation metrics
- The success of the course project — measured through “customer” satisfaction —, will help judge the value of the content produced from this project
- Improvement in the student communication skills will be tested throughout the course assignments, and later on through the Computer Science Department’s written and oral capstone requirement
- Whether course material — in particular integrating development of communication skills through collaboration with the peer-tutors — is being adapted to/shared with other Computer Science courses, Departments and institutions is an additional measure of success
- An ultimate evaluation metric for the success of this project is the amount of recognition it gets for successfully completed community-based projects that are of benefit to the greater University and/or Pittsburgh community.

## **Summary**

The Immersive Software Engineering plan has the potential to introduce new and exciting courses that allow Computer Science students to combine theory with the capstone experience, while building community-based projects. Because the success of such projects hinges not only on solid technical skills, but also good communication skills, such courses will integrate written and oral communication with programming assignments. This proposal will essentially provide and test-drive the necessary integrative framework which brings together resources from Computer Science, the Writing Center, and the Oral Communication Lab, beyond which the project will be self-sustainable.

**References:**

[1] S. Krishnamurthi, "Software System Design", 2009.  
<http://www.cs.brown.edu/courses/csci1900/2009/>

[2] S. Gaudin, "Dual Roles: The Changing Face of IT", 2005.  
<http://itmanagement.earthweb.com/career/article.php/3523066>