Creating and Guiding Mobile Device Research Projects

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Abstract— **This paper describes a highly effective two-semester client-oriented team-based approach in which students get their first "real" research and development experience in a carefully guided environment that fashions theory into product. Examples used describe how a problem space in mobile devices can be scoped to design tenable software solutions and then how to build one of these designs into what a customer seeks, thereby effectively providing what society increasingly requires from educational institutions in developing mobile device applications.**

Keywords-smartphones, capstone, education

I. INTRODUCTION

Educators owe it to their students to continually update curriculum to ensure they are teaching the latest technology and, in doing so, capturing the imagination of their students. As smartphones continue to grow in popularity among students and become more pervasive across campuses around the world, we have discovered that many of our Computer Science and Information Technology students want to become smartphone developers. Using this as our motivation, we have offered our students research projects focused around mobile device and smartphone development for the past five years. This paper discusses our "capstone" course, followed by a description of two recent capstone projects. The paper then discusses smartphone work that we have conducted outside of our capstone projects as well as where we see smartphone development fitting into our curriculum in the long term. The paper concludes with a collection of lessons we have learned while creating and guiding mobile device capstone projects for other educators to consider.

II. THE INTEGRATIVE EXPERIENCE

At the United States Military Academy at West Point, NY every student participates in an integrative experience. In the Department of Electrical Engineering and Computer Science, these nine-month-long team projects are achieved through two successive, 3.5-credit hour courses, consisting primarily of EE, CS, and IT majors. These two courses over two semesters introduce essential elements of design and project management and require students to draw upon their cumulative academic experiences to address an open-ended, real-world design problem by successfully executing an engineering process in designing, building, and testing software and electronic systems or sub-systems as a team. Students from all three majors are assigned to unique team projects, with a goal of satisfying the needs of a client, who is either a member of the faculty with a specific need for research or an "actual" client with a requirement for a product. Teams usually consist of two to six students with some representation from each of the three majors. This diversity in teams contributes to a student's ability to apply their own expertise to their project. In addition to the team members and client, each team is sponsored by a faculty advisor who is responsible for guiding and assisting the students throughout their capstone experience.

Course requirements include periodic in-progress reviews, written and oral reports, and completion of the iterative design, build, and test cycle for a functional system. The design must also consider the social, political, technological, security, and economic aspects of the project. By the end of the second semester a functional system or product is displayed during Projects Day, with some going on to national undergraduate engineering design competitions such as the Rochester Institute of Technology Student Design Contest [1] and the Massachusetts Institute of Technology Institute for Soldier Nanotechnologies' Soldier Design Competition [2].

Working with undergraduate students on essentially graduate-level undertaking necessitates extra attention. For example, weekly meetings are absolutely essential to ensure progress is made. What undergraduates fail to grasp at first is that research can seldom be achieved by pulling an "all-nighter" in order to catch up. Little steps need to be taken frequently and with oversight. Another enhancer to prod their involvement is regular peer evaluations in which team members evaluate contributions and efforts of their teammates.

Similarly, faculty advisors also need to be held accountable. Not all teams do poorly because their work is poor, rather they are poorly guided. In short, the course director of capstone teams needs to monitor advisor involvement throughout the project development process. Advisors generally have the best of intents, but most also have a number of competing interests on their time. Consequently, they can find themselves behind the "power curve" as much as their team and not be able to surge in time to meet deadlines on time and to standard. The expected end-state of our projects is not generally a "real" software product that will be deployed and maintained, rather it is a proof of concept that will be passed to the client for further development, deployment, and eventual maintenance. This

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14. ABSTRACT
This paper describes a highly effective two-semester client-oriented team-based approach in which students get their first ?real? research and development experience in a carefully guided environment that fashions theory into product. Examples used describe how a problem space in mobile devices can be scoped to design tenable software solutions and then how to build one of these designs into what a customer seeks, thereby effectively providing what society increasingly requires from educational institutions in developing mobile device applications

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alleviates the need for faculty or students to commit to long term project maintenance.

Ideally, a project entails a real-world need to be solved by practical application of research. For undergraduates to approach such an endeavor for the first time can be daunting for them. Typically, undergraduates seldom delve into work outside the type usually conducted in controlled lab environments or that have not already been solved. The approach described here relies on the belief that more learning can be achieved by providing a platform for students to extend their individual lab efforts to actual prototype development as a multidisciplinary team. Moreover, this kind of enterprise is excellent preparation for employment after college, be it in the commercial world or in higher levels of academia [3].

III. MILSPACE MOBILE (IPHONE)

One of our first attempts in a mobile device capstone project began with the vague idea that we would spend a semester teaching a small group of students how to develop on the iPhone platform. From that, we found a project that students could easily relate to and one that would provide some
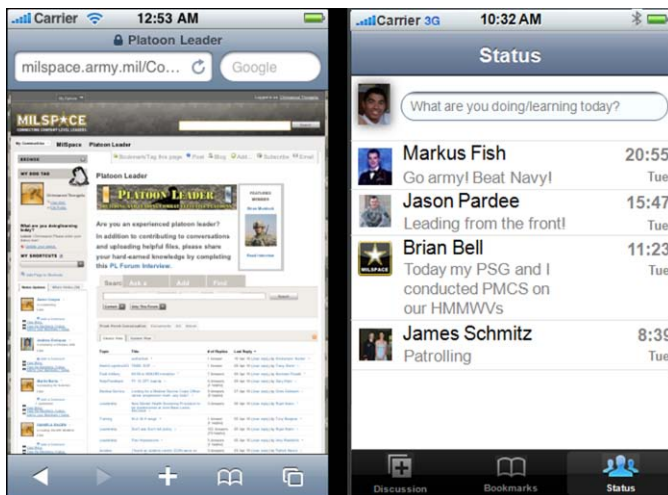

Figure 1. Creating a forum more readable for mobile subscribers.

future utility. MilSpace is a military only social forum that is targeted at platoon leaders and company commanders in charge of 30 to 130 soldiers respectively [4]. It could be easily described as a form of Facebook for Army leader development. MilSpace provides a forum where past, current, and future platoon leaders and company commanders can exchange ideas and learn how to be more effective at what they do. The first job that most of our students will undertake after their graduation from the Academy is that of platoon leader, so we decided to focus the project on the platoon leader forum [5]; for all intents and purposes any relevant forum of interest to students anywhere would suffice.

We begin every capstone project by having the students identify the very root of the problem that they are trying to solve. The problem description written by the students was that "The Soldier community is not taking full advantage of mobile platforms to communicate ideas and share professional knowledge." [6] Their proposed project was intended to

"Create an iPhone application that increases leader effectiveness by incorporating MilSpace's professional forums onto a mobile platform, providing on-the-go access to cutting edge knowledge." [6] This is akin to helping low to mid-level managers share information with each other to provide grass-root-assistance in how they carry out their professions. Figure 1 demonstrates a simple example of the effectiveness of this project. The left hand side demonstrates what the Milspace website looked like when viewed in the iPhone's Safari browser. The right side shows the same information in a far more readable format when incorporated into the MilSpace Mobile iPhone Application.

From a teaching standpoint, the most difficult part of leading a capstone project like this is getting students to a level of competency on the platform so they can actually develop an application from design through testing. The primary programming language that we teach students is Ada95, although they do get limited exposure to Java, Python, Ruby, C, and C#. Since students come into the project with limited programming experience in a mobile environment, and the bulk of their fall semester project time is focused on designing their project, we introduce a number of small projects to bring students up to an experience level suitable for completing their project.

IV. AUGMENTED REALITY (ANDROID)

As with the previous year, the next smartphone project started with some vague ideas and a small selection of project possibilities, with the intent of leaving the final, viable project choice up to the students. Our goal is to allow the students to choose the specific scope of their project to allow them more ownership of the work they will conduct. After selecting their project, the students identified their problem as: "Develop an

Figure 2. These screen captures demonstrate how icons can be depicted either as geo-rectified overlays on Google provided satellite imagery (top) or in an Augmented Reality perspective (bottom).

application for a smartphone device that provides quick reference battlefield data to leaders." [7] The application was designed to provide soldiers the ability to quickly orient themselves to manmade and physical objects around them by using graphics overlaid on top of the live camera image from the smartphone's screen. The scope of the project restricted the students to identifying friendly and enemy units, but is easily extendable to identify other objects of interest. The scope of the project also forced students to use many of the features of the smartphone, including the compass, accelerometer, gyroscope, GPS, and data communications. Figure 2 demonstrates early thoughts on how the students wanted their application to function. The image on top shows a Boeing provided Situational Awareness application where unit positions are overlaid on Google provided satellite imagery, while the bottom image was manipulated to demonstrate the initial design of how the students wanted their Augmented Reality user interface to look [8]. The final design of the Augmented Reality project resulted in an application that pulls together Boeing's Situational Awareness application for unit data and pushes it into the open source Mixare Augmented Reality engine [8] for display.

In our previous smartphone development projects, we learned a significant amount about how to better guide students through the process of learning how to design and develop for the smartphone platform. Although we had a year of experience working with students as they developed on the iPhone platform, we decided to move to Android for several reasons. Most importantly, the project was sponsored by Boeing, and was required to use the Boeing provided SOSCOE [9] framework which was not available on iPhone at the inception of the project. Although our sponsor directed the use of Android, we have several additional reasons that had been discussed prior to the final decision being made. First, our students are familiar with Windows and Eclipse, which helps us avoid the significant hurdle of student familiarity with their development platform and environment. As a Department of Defense entity, West Point is a primarily PC based campus connected to a government network. This PC-centric limitation made using MacBooks and iPhones during the MilSpace Mobile project significantly more difficult. It also made the selection of Android for the Augmented Reality project much easier. The students also have some basic familiarity with Java and XML, so unlike working in Objective-C on the iPhone, Android provided us with the ability to use knowledge that our students had already gained in other courses. Lastly, since anyone can add applications to the Android without a paid developer account, the overhead involved in simply installing the application onto the device is significantly reduced.

V. OTHER MOBILE WORK

A. Independent Study

In addition to our capstone work surrounding mobile device development, we have had students complete two separate independent study projects focusing on smartphones. In one of these projects, a student extended the work from a prior year capstone project onto Android. The student from the prior year's project developed an open source, low cost, 360 degree geo-rectified photo capture platform, similar to Google Street View, called Phototrail [10]. The intent of the follow-on independent study project was to be able to quickly capture 360 degrees of photos using an Android device and then stitch the photos together into a flat panorama. To save processing on the mobile platform, the student decided to send individual pictures to a server where the stitching would take place. The end state of his work was a Google Earth kml file that contains the photos, their GPS coordinates, elevation, and direction of display. This combination of information gives users easily navigable images that provide a full 360 degree perspective as demonstrated in Figure 3.

B. Summer Internships

During each summer, West Point cadets are invited by both Department of Defense organizations and commercial
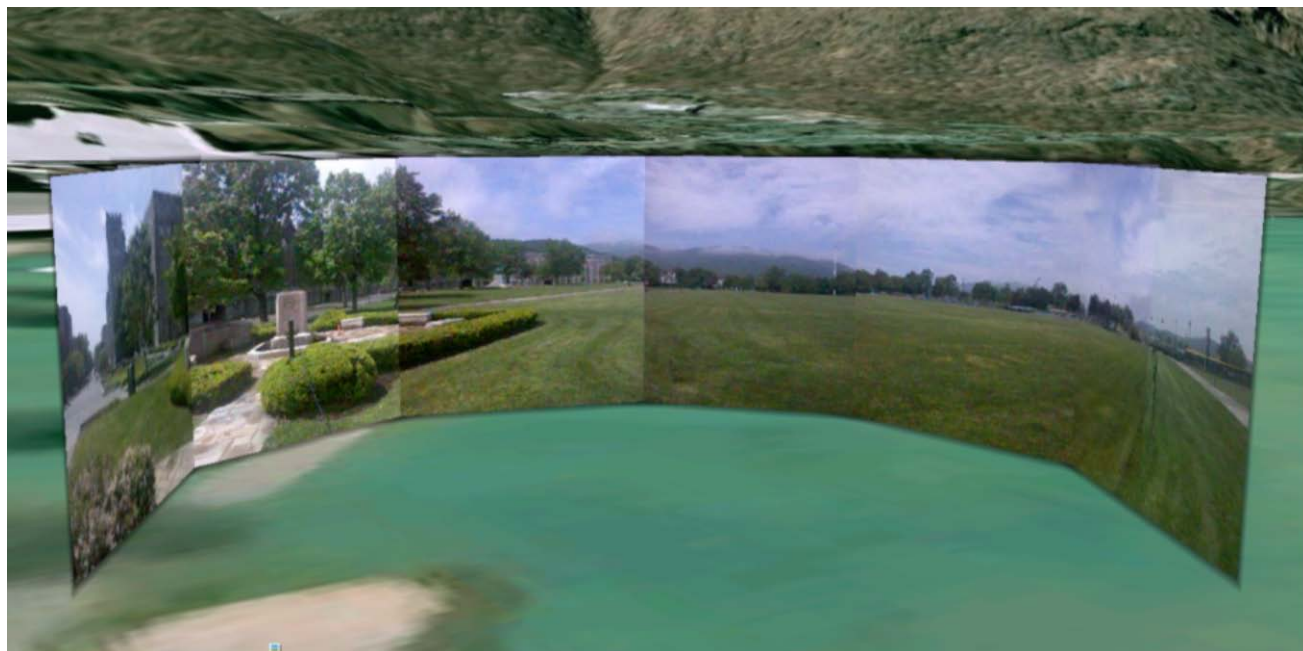

Figure 3. Creating a 360 degree navigable stitched panoramic image in Google Earth using Android technology.

companies to participate in three to five week internships. During the summer of 2010, four students were invited to spend three weeks with Boeing working on military focused Android applications using their SOSCOE toolkit and infrastructure [9]. In their three weeks with Boeing, the students were able to develop three applications that would be used for submitting tactical reports from a forward area of operation. Once they completed these three applications, the students were able to consolidate the apps into one complete reporting application with a framework to easily add additional reports in the future.

While neither the independent study project nor the Boeing internships were directly related to capstone projects, they did help us to identify what our students are capable of and, moreover, provided us with new ideas for future capstone projects (as well as motivated students to pursue them). We have used these experiences to help us in scoping our capstone projects to ensure that the students have a full academic year's worth of work in a project and, equally important, are able to demonstrate a completed application at the culmination of their capstone.

VI. FUTURE WORK

To meet what we believe will be the demands of our graduates, we currently have an inventory of smartphones with more than one per CS and IT major, but approximately one for every two when CS and IT minors are included. These smartphones are being gradually included in class lessons for different courses or dedicated to specific projects. For example, our student minors taking our Distributed Applications course will use the MVC (Model View Controller) Framework in Ruby on Rails to detect a mobile device and provide different views. They will then use JQuery Mobile to provide a mobile view. Using the smartphone they will demonstrate that the server can detect the client, and then render AJAX enabled mobile friendly views that provide the same functionality as a standard web browser on a desktop computer.

For our CS and IT majors involved in more complex research projects, we have several initiatives. One is to use smartphones as an interface to control autonomous and semi-autonomous robots using the Robotic Operating System (ROS) [11]. As part of this interface, these smartphones will allow the user to pull data from the robot's network and push this data onto another network. In another project we are using the smartphones to control small unmanned ground and aerial vehicles.

VII. CONCLUSION

Through our five years of capstone projects and non-capstone mobile development work, we have identified several worthwhile lessons that we will leverage to improve future projects. First, we have discovered that although students require some background in developing on mobile platforms, most of them can easily learn the subject while working on a specific application within a well-defined project. Second, we have learned that we must ensure our projects are scoped in such a manner that they can be completed by the end of the 9 month capstone experience. Students who succeed in slightly smaller projects feel intrinsically motivated and inspired to pursue future contributions more than students who fail to complete larger and likely untenable projects. Third, we compel the students to follow a software design process as a team throughout the first semester before having them dive deeply into application development during the second semester. Fourth, although familiarity makes things easier, the platform that students learn to develop on is largely immaterial and can be changed to support sponsor requirements or to make the best use of school resources. Fifth, we have found that students who are permitted to have some control over the project selection process will be significantly more motivated throughout the entire capstone process. This self-selection process is greatly facilitated by students who work on mobile device development projects as interns over the summer because many of them desire to continue their summer work into the academic year. Sixth, while an ideal course will have enough mobile devices for each student to work on their own, smartphone emulation technology is at the point that it is still possible to teach mobile development without access to individual devices.

We are always seeking new ways to inspire students, and mobile device development is serving both faculty and students very well in this regard. The "digital natives" now entering college are far more likely to have used mobile device applications and appreciate their utility more than any student year group before them, so this trend should continue for years to come.

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