Educational Aspects of Undergraduate Research on Smartphone Application Development

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ABSTRACT

Smartphones have become commonplace in today's society. There seems to be a mobile application for every conceivable use, expect one. Smartphones have been conspicuously absent in higher education. This research examines the use of mobile applications (apps) in the higher education setting. In addition, it evaluates the potential for including smartphone application development in undergraduate computer science curriculum. This paper will present a variety of smartphone apps that were developed by undergraduate researchers for use for use by students and faculty in a university environment, and apps developed to enhance the educational experience in the classroom. We also study the efficacy of the inclusion of smartphone app development in the computer science curriculum and modes for its inclusion.

1. INTRODUCTION

With the proliferation of smartphones, the Computer Science Department at Indiana University of Pennsylvania became interested in the relevance of smartphone technology to undergraduate education. As a result, a grant was received to evaluate the potential for smartphone application development in the undergraduate curriculum and the development of smartphone applications (apps) for campus and classroom use. The specific objectives of the grant were:

1. To determine how smartphone application development should be integrated into existing courses in the Computer science curriculum.

2. To determine whether a new course in smartphone application development is warranted.

3. To evaluate the potential for campus-specific GPS tracking and mapping.

4. To evaluate the potential for the integration of smartphone applications with the campus registration system and the ability to download scheduling information to the smartphone's calendar.

5. To evaluate the potential for smartphones in the classroom.

With the advent of mobile computing and cell phones, it was believed that these new technologies offered a novel method of providing an alternative learning option. Early attempts to utilize mobile wireless technologies included text messaging, eBooks, sharing educational resources, access to mobile libraries, and mobile learning environments. However, the use of smartphones transcends the simple concepts of mobile computing. Many of these new concepts will be presented in this paper.

Currently, smartphones are frequently not accepted nor utilized in higher education. This is primarily due to the fact that few educational applications exist. While it was originally believed that the impact of mobile phones would be found in the use of Short Message Service (SMS), it is now agreed that smartphones will have an even greater impact through the use of apps [1]. Some researchers postulate that in the near future, many higher education institutions will require smartphones for students and faculty members [2].

Today's smartphone has constant Internet connectivity and incorporate an operating system that allows add-on applications, or apps [3]. The two most common operating systems are Android, a Linux-based open source operating system, and iOS, a proprietary operating system used exclusively by Apple iPhones and iPods. Students are nearly equally divided between the two operating systems with 43% using Androids and 42% using iPhones [4].

Smartphone sales totaled 486 million in 2011 [5]. This was an increase of 62.3% over the prior year. It is projected that smartphone sales will increase to 1.5 billion units in 2016 [6]. It has been projected that by

2020, smartphones will become the primary means of accessing the Internet [7].

Research has shown that 57% of college students regularly use a smartphone, 60% feel addicted to their smartphone, 75% sleep next to their smartphone, and 97% use their smartphone for social networking [4]. The same research also reveals that 40% of students have used their smartphone to prep for a test. Thus, a significant portion of students are already accustomed to the use of smartphones for academic purposes, as well as social ones.

Although many professors view smartphones as a distraction to students in the classroom, other professors, including Williams and Pence [8], believe that smartphones can be used to manage students' attention. They label chemistry lab instruments with QR codes. The two-dimensional QR barcodes can be scanned by a smartphone which will then display the correct operating instructions for that instrument. Similarly, the QR code on a bottle containing a chemical can be scanned to display the contents, use, and other pertinent information regarding the chemical.

In general, technology-aided learning has experienced three paradigm shifts: e-learning, m-learning, and context-aware u-learning [9]. In conventional e-learning, the computer simply provides information in a manner similar to a textbook or lecture. In m-learning (mobile-learning), this information is provided through mobile devices and wireless communication. M-learning has three key components: mobility of technology, mobility of learners, and mobility of learning processes. Mobile devices allow both synchronous and asynchronous learning. A major paradigm shift arises with context-aware u-learning (ubiquitous learning). This requires that the mobile device be equipped with sensor technology, as well as wireless communication. Smartphones provide the necessary sensor technology for context-aware u-learning. Context awareness allows sensors to detect student learning behaviors in the real world and provide adaptive learning capabilities. Liu and Hwang [9] conducted a case study to demonstrate context awareness. Plants in a butterfly garden were labeled with RFID tags. Students moved around the garden and scanned the RFID tags. The smartphone detected a student's location using its global positioning system (GPS) capability, recognized the RFID tag information, and asked the student to identify features of the plant. If the student provided incorrect answers, the application directed the student to re-examine the plant.

The undergraduate research conducted with the grant involved learning the skills necessary to develop smartphone apps, developing apps for higher education, and determining the feasibility of incorporating app development into the Computer Science curriculum. Section 2 provides background information on the development framework. Sections 3 and 4 discuss app development and curricular issues, respectively. Finally, conclusions are presented in Section 5.

2. BACKGROUND

Investigation has determined that a major factor in people's resistance to adopting smartphones in education is the ease of use as perceived by users [10]. This makes it imperative that any apps be easy to use by students of any background and that the apps be seamlessly integrated as a single cohesive unit.

The team decided to concentrate on the objectives related to development of apps (objectives 3, 4, and 5) before addressing the curricular issues (objectives 1 and 2). The undergraduate students were able to become sufficiently proficient with the Android/Eclipse with ADT plug-in development environment to develop apps in a relatively short amount of time. It became apparent that upper-level students had sufficient knowledge of Eclipse and Java programming to readily adapt to smartphone development. This supported the objective to evaluate the efficacy of introducing smartphone development into the curriculum.

Concurrent with this study, the university began evaluating a suite of mobile applications developed by SunGard, a software technology vendor providing solutions to for financial services and education. The SunGard mobile offering is a Motorola Solutions' RhoMobile [11] based framework that provides a mobile extension to Banner, a student registration and records system. The primary benefit of RhoMobile is cross platform portability across several mobile platforms including iPhone and Android.

Our research team evaluated the SunGard/RhoMobile framework in the context of the objectives established for this research project and elected not to use it for this study. The main concerns were the excessive use of resources, lack of native look and feel, lack of conformance to published guidelines, and limited integration support between apps. Thus, the team decided to focus on the Android platform using the native software development kit (SDK) and Eclipse IDE (integrated development environment). It was further decided to defer development on iOS to future work. By doing so, the team was able to leverage the aforementioned skills and concentrate on providing a set of apps which performed well, had native look and feel, were rich in function, and were integrated among themselves and with other external native apps. What is emerging from this effort is a synergistic suite for campus information and classroom engagement.

3. APPS FOR CAMPUS AND CLASSROOM

The first challenge was to develop a set of apps that would promote student use. The apps would address needs for campus information and to enhance the educational experience. The apps should be easy to use and provide necessary services to students. Additionally, each app should be integrated with other smartphone capabilities. For example, if a phone number is displayed, one should be able to touch the number to initiate a call. The list included interactive GPS-enabled campus map, campus directory, course registration, schedule app, and apps for use in the classroom.

GPS Tracking and Mapping

One objective was to investigate the potential for implementing a campus-specific GPS tracking and mapping application. The use of Google Maps was initially investigated using the Sungard/RhoMobile framework; however, it was found to be inappropriate for several reasons. First, problems were experienced with Google Maps tiling which produced erratic behavior when repositioning, spreading, and pinching the image. Another problem was that the image delivered by Google Maps had incorrectly labeled buildings and did not reflect recent changes due to construction and re-routing/closure of roads and walkways. Another problem was encountered in Google's use of Keyhole Markup Language (KML) placemarks. KML is the file format used to display geographic data. Unfortunately, the use of KML placemarks to denote buildings and other points of interest on the Google Maps resulted in a great deal of clutter which inhibited effective use.

The next approach was to use an in-house campus map in bit-mapped format. This image provides current information and is updated on a regular basis. To establish positioning on the map, GPS coordinates for the upper left and lower right corners were recorded. A problem was found because the image is not geographically accurate in dimensions and in north-south orientation. Thus, the initial attempt to locate someone's position on the map often misplaced them. Another approach was sought to rectify this inconsistency. One feature found distributed around the campus map is the position of all emergency boxes. The GPS location of these emergency boxes was recorded and mapped to each box on the campus map. When trying to place an individual on the map, the individual's GPS position is triangulated with the recorded GPS positions of the closest emergency boxes. While positioning improved, some inaccuracy in positioning the smartphone on the map remained. Investigation revealed that the emergency boxes on the map image are not geographically or spatially accurate. The map only provides the relative position of buildings, sidewalks, roads, and other campus features. However, the positions are not consistent in spatial accuracy. Subsequent algorithms are being developed to weight positioning based on the relative distances of the GPS landmarks and the number of landmarks to be considered. Another problem that was encountered is that when pinching and spreading the map, the image can become distorted. The solution for this was to use a vector graphics image to render different resolutions in real time..

Several enhancements to the campus map are in various stages of development. One is to establish the orientation of the smartphone user so that the map rotates to always display straight ahead at the top of the display. Other features include providing directions to a particular building based on one's current position and locating parking lots. It is desirable to allow the user to touch a particular building and have the internal map of rooms displayed. Also, we are investigating the partitioning or grouping of map features such as academic buildings, administrative buildings, student housing, and parking lots. To date highlighting of a selected building with a placemark and a pop-up dialog of the building information has been completed.

Campus Directory

An early success was the development of an app to access the campus directory. This app leverages an existing AJAX-based service to the university LDAP directory. LDAP is a protocol which allows a program to access information from a designated server. The app enables look-up of students, faculty, and staff using a "query by forms" on any combination of first name, last name, department, email, and role (e.g., student, faculty). Found entries are presented in a list and full information on an entry is displayed via a tap.

While the campus directory by itself is of moderate value, its true significance is realized when integrated with other apps. Activating the Smartphone's email and dialer apps was an obvious integration that was first implemented. Another success was integration with the Smartphone's native contact app. A found entry could be readily saved as a contact thereby alleviating the need for time consuming future lookups over the network for information that had already been accessed. Lastly and most interesting was integration with campus map. For faculty and staff entries, an icon on the display screen activated the campus map with their office location highlighted.

The campus directory was first implemented using the Sungard/RhoMobile framework and then implemented directly using the Android SDK. The Android SDK implementation was found to be superior in performance, feel, and integration with other apps. The major problem with the Sungard/RhoMobile implementation was that it encountered limits when integrating with other apps.

Registration and Scheduling Data

The next app to be addressed was one to access the student registration system (Sungard's Banner) in order to download the class schedule for both students and faculty for a selected semester(s). The schedule information, which included course name, location, meeting times, and the assigned instructor, was downloaded and stored in a local database. The local storage eliminated the need to submit credentials and the network traffic was reduced to a few times per semester. Yet the student or faculty schedule is readily accessible at your "Thumb-tips"[1].

As with the Campus Directory, integration with other apps proved to be of significance. In addition to storing the schedule information in a local database the Smartphone's native calendar app can be called, at the touch of a single button, to insert meeting times of all classes into the user's smartphone calendar from the start of the semester to the end. While not implemented at this time, alarms could be set for a certain number of minutes before class starts (and class ends for faculty). As with the campus directory, a map icon activates the campus map app to display the map with the classroom location now highlighted. Furthermore, a directory icon by the faculty name activates the campus directory to display the directory information of the faculty.

For faculty the schedule app goes an interesting step further; the class roster for each class is included in the download. In addition to the student's name and major, the student's picture is downloaded and stored in a local database. Thus on the first day of class, a faculty member can have in the palm of their hand a list of students with their pictures. Next to each entry are two icons used to activate the Smartphone's native email app. The first initiates an email to the student. The second initiates an email to the faculty member with a subject line referencing the student. The later facilitates "notes to self" to take care of when back at their office.

Of paramount value, the schedule app has the potential to automatically configure an infrastructure that facilitates new student/teacher interactions in the classroom which exploit the use of smartphone technology. The schedule places both faculty and students at a given location and known times. The only additional information would be a list of rooms to IP numbers of the podium computer within each classroom. A server then running on the podium computer could act as the broker for communication and enable instructor controls. The server will only accept connections from the students and faculty registered in the room at the given time.

[1] A play on "Information at your fingertips", Bill Gates, COMDEX keynote speech, 1994.

Potential Use in Classrooms

Prior to our work, several colleagues had already initiated experiments with existing smartphone technology in order to enhance the classroom experience. For example, use of Google searches via the phone's native browser enables students to perform in-class and real-time research to questions posed by the instructor. Found information could be then be used to drive a discussion. Another example exploited texting to bring thoughts from external parties into the classroom. Here the instructor posed a question and students were asked to "Text a friend" the question. Replies could then be presented and discussed. For a last example, another instructor experimented with Poll Everywhere [12], a commercial service to provide instant audience feedback. Questions together with a set of choices can be included a presentation. Students would then text their answer to a given number. The answers are then aggregated and a live bar graph generated. While these examples are simple in nature they provide fertile ground for innovation for in-classroom apps. It is here where the team implemented several trial apps to streamline the intended function.

The use of Google within the classroom is an effective tool to promote classroom participation. However, it suffers from relying on students to verbally articulate what they see on their screens. Furthermore the size of the phone's display was a major impediment. To address these problems a share a page app was developed. This app simply registers itself on the smartphone as a service that can respond to a share event generated by a browser. Once a student has found a web page they wish to share with the class, the browser's share menu option could be used send the page address to the app. The app would then send the address to a server on the instructor's podium computer which would in turn activate the desktop browser to display the page with the entire class.

"Text a friend" is an interesting exploit of social media that can be immediately used within the classroom; however it too has a major issue. After posing the question, valuable class time is consumed while every student types in the question using their phones keyboard, which involves more time than standard full size keyboard. To eliminate this loss of time an app was developed to automatically supply text to the phone's text app. In this case, the instructor initiates process by sending a question, prepared in advance, from a server on the instructor's podium computer to the student's phones. The text a friend app on receipt of a question would activate the phone's texting app and supply the question as the body of the message. Students need only enter the phone number of their friend to complete the task. While not yet implemented, replies could be sent back to the instructor using techniques similar to the previously discussed with the share page app.

Poll Everywhere is a polished commercial product that works very well and several instructors have reported good success. From a functionality viewpoint, it has only a few issues and those can be considered minor. For example, the need to enter text numbers is a slight inconvenience that may be subject to miss-entry. The biggest downside of Poll Everywhere is that fees are imposed when use of the service exceeds given limits.

The team is currently investigating an app based alternative to Poll Everywhere. The polling app would work in conjunction with a central server, again running on a podium computer. At the server side, instructors can create poll questions either prior to class or spontaneously during class. During class the instructor can send a question to the student's smartphones to which students may select their response. The question will be placed in a multiline textbox, and the answers will be placed in a scrollable list allowing for a variable number of answers ranging from true/false questions to multiple choice questions. The student (client) will select an answer using a radio button, and press submit. The user's response will be sent to the server and placed in a database.

We intend to allow the instructor will have multiple methods of poll and survey creation. Furthermore, the instructor will be able to create polls from within PowerPoint. In order to use PowerPoint, an add-in must be installed. This will be achievable with a simple windows installer. The add-in will allow the instructor to create polls from a form within PowerPoint merely by clicking "Create Poll" under the insert tab on the ribbon. The add-in will also provide a method of inserting a number of dynamic graphical representations of the response data directly into a presentation. The dynamic aspect of the graph implies that it will change as the response data changes.

The results can be displayed on a screen in the classroom in a dynamic graphical presentation that changes in real time as responses are received. The app has multiple uses such as stimulating conversation, checking whether students understand concepts without testing, and conducting quizzes. The real-time feedback is advantageous to both students and instructor.

Other Apps and Future Work

In addition to the apps describe above the team has develop a number of other apps. These include use of available campus RSS feeds to display campus news, display of a student's academic advisor, and access to information about available majors. All of these are implemented to using a native look and feel.

Future applications include a bus schedule app which uses one's GPS location to provide the schedule for that location. Another potential app will allow prospective students to request information and schedule a campus tour. Currently, all apps have been developed for the Android. With the prospect of further funding, we intend to port the apps to iOS for the iPhone.

4. CURRICULAR ISSUES

Objectives 1 and 2 of the grant dealt with curricular issues:

1. To determine how smartphone application development should be integrated into existing courses in the Computer science curriculum.

2. To determine whether a new course in smartphone application development is warranted.

Integration of App Development into Existing Courses

During the development of the apps discussed in the previous section, it was noted that upper-level Computer science majors were able to quickly learn the requisite technologies and adapt to the development mode required for smartphone apps. This confirmed the hypothesis that app development could be incorporate into existing courses. One potential course is our Software Engineering Practicum which is a capstone course. Development of a small to medium sized app would be an ideal project for students to undertake in this course. Such projects would provide practical application of skills acquired in their programming, database, and software engineering courses while at the same time challenge students to research and "learn on the job" the knowledge and skills of emerging technology, thus creating an environment that reflects what they will experience in their careers. It is believed that such projects are of appropriate size to be developed by small teams of students (2 to 3) over the course of a semester. During this period each team will have sufficient time to; assessed requirements, sufficiently researched the capabilities of new technology, formally developed specifications, acquired missing technical skills, completed implementation and testing, and packaged the resulting deliverables.

Potential for New Courses in App Development

Although upper-level majors were able to learn the technologies needed for app development, they found many issues that require further investigation. These include; use of low level graphics, inter-app communication, coping with variance of hardware such as screen resolutions, interfacing with audio and video both from stored media and from the phones peripheral devices such as the camera, interaction with sensors, and greater breath of network services.

Therefore, there is great potential for creation of a new course in app development. The number of universities already offering courses in mobile application development is growing. The list includes San Diego State University, the University of Illinois, and the University of Washington. A course devoted to app development would allow students to gain an understanding of all relevant technologies and skills for app development. In addition, a new course would provide sufficient time to not only understand development for the Android, but also for the iPhone.

5. CONCLUSION

In the course of investigating the user requirements, it was discovered that integration between apps is vitally important to usability and acceptance, and thus, the success of the project. It should also be noted that all of the in-classroom apps involve interaction with a server located on the instructor's podium computer. Therefore, these apps require an infrastructure with a minimal configuration. Access to the podium computer requires the IP address of the particular classroom making the schedule app the key to the success of the in-classroom apps.

This research has successfully developed smartphone apps for campus and classroom use. The educational aspects of this development are evident. The students have gained an understanding of developing apps for a modern, ubiquitous technology. The research required for the apps to operate correctly, such as the development of mapping and novel triangulation techniques, have introduced undergraduate students to research methodologies. The project has also allowed us to evaluate the potential for campus-specific GPS tracking and mapping. In addition, we have demonstrated the potential for inclusion of smartphone app development in our curriculum by confirming that upper-level students have sufficient knowledge to adapt to the required technologies. This supports the objective to evaluate the potential of introducing smartphone development into the curriculum.

6. ACKNOWLEDMENTS

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7. REFERENCES

[1] S. H. Kim, C. Mims, & K. P. Holmes, "An Introduction to Current Trends and Benefits of Mobile Wireless Technology Use in Higher Education," *Association for the Advancement of Computing in Education Journal*, Vol. 14, No. 1, 2006, pp. 77-100.

[2] C. Houser, P. Thornton, S. Yokoi, & T. Yasuda, "Learning on the Move: Vocabulary Study via Phone Email," *Proceedings of the 9th International Conference on Computers in Education*, 2001, pp. 1560-1567.

[3] F. Yu, "Mobile/Smartphone Use in Higher Education," *Proceedings of the 2012 Southwest Decision Sciences Institute*, 2012, pp. 831-839.

[4] A. Alexander, *How Reliant Are College Students on Smartphones?* Retrieved from http://ansonalex.com/technology/how-reliant-are-college-students-on-smartphones-infographic/

[5] T. Ahonen, *Smartphone Final Numbers 2011*. Retrieved from http://communities-dominate.blogs.com/brands/2012/02/smartphone-final-numbers-2011-all-the-stats-including-q4-by-handset-brands-operating-systems-and-ins.html

[6] P.-E. Gobry, *ANALYST: Smartphone Sales Will Dwarf PC Sales This Year And Reach A Staggering 1.5 Billion Per Year By 2016*. Retrieved from http://articles.businessinsider.com/2012-02-29/tech/31109577_1_smartphones-pc-sales-internet

[7] D. Caverly, S. Ward, & M. Caverly, "Techtalk: Mobile Learning and Access, *Journal of Developmental Education*, Vol. 33, No. 1, 2009, pp. 38-39.

[8] A. Williams & H. Pence, "Smart Phones: A Powerful Tool in the Chemistry Classroom," *Journal of Chemistry Education*, Vol. 88, No. 6, 2011, pp. 683-686.

[9] G. Liu & G. Hwang, "A Key Step to Understanding Paradign Shifts in E-Learning: Towards Context-Aware Ubiquitous Learning," *British Journal of Educational Technology*, Vol. 41, No. 2, 2010, pp. E1-E9.

[10] Y. Wang, M. Wu, & H. Wang, "Investigating the Determinants and Age and Gender Differences in the Acceptance of Mobile Learning," *British Journal of Educational Technology*, Vol. 40, No. 1, 2009, pp. 92-118.

[11] RhoMobile, Motorola Solutions, http://rhomobile.com

[12] Poll Everywhere, Poll Everywhere Inc., http://www.polleverywhere.com