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An 'Engineering-Health Science' Interdisciplinary Approach to Promoting Mobile Technology for Multidisciplinary Applications*

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This is a progress report on our ongoing interdisciplinary project to promote mobile technology for multidisciplinary applications. The project consists of collaborative efforts between engineering and health science faculty and students in using mobile techniques to collect, transmit, analyse and store health data. Main techniques of wireless data acquisition and transmission, as well as key issues such as privacy and data security are addressed through joint course instruction sessions and laboratory experiments. The project is initiated via a Health Science Health Care Informatics course and an engineering Wireless Communications and Systems course. Health science students are to learn engineering techniques of effective use of wireless communications systems, while engineering students are to gain knowledge of applications in health sciences. Upon successful implementation and further improvement, this model can be further expanded into other areas such as natural sciences and business administration where the same concepts can be applied using different datasets. The interdisciplinary approach of using mobile technology will result in a revolutionary and exciting learning environment with truly multidisciplinary applications.

Keywords: mobile technologies; multidisciplinary applications; health science

INTRODUCTION

LEARNING IS A TOP PRIORITY at Western Carolina University (WCU), a regional comprehensive institution. WCU is recognized as a leader in the adoption of instructional technology and, in 1998, it became the first of the University of North Carolina system to require a networkable computer for admission. WCU boasts that the residence hall students have a port by every pillow. It is recognized as one of the nation's 100 most wired campuses; its mobile technology vision is pervasive and is emulated by an aggressive wired deployment.

Besides visionary leadership, the broadest deployment of mobile technology will result from strong demonstrations of its power in enhancing student learning. Our project accomplishes this goal with a broad multidisciplinary team approach that brings together instruction on wireless technology with health data management and applications that collect the data in the field. Health Care Informatics (HIA 420) is the core course with team members from engineering and technology in the wireless communications and systems course (TEL 444), and field data collection using mobile technology from Athletic Training (ATTR383), Food Safety (ENVH330), Waste Water (ENVH465) and Epidemiology (ENVH475). Success in this project, with its broad interdisciplinary impact, will powerfully support faculty in the development of technology-rich course offerings and enable a broad rollout of mobile technology into instructional reality.

A major teaching and learning issue is the disconnection between academic disciplines of using mobile technology. Engineering and technology students who understand the theories of operation of mobile technologies do not necessarily understand the application issues associated with health science, while health science students may not be aware of the application-specific wonders that can be performed by engineering professionals. It is imperative to introduce an innovative method to bridge this learning gap. Our interdisciplinary approach to use of mobile technology creates an integrated learning environment by teaming students to address issues from both disciplines. For instance, within this mobile environment, health science students will learn how to collect real-time athletic training data in the training field, and engineering and technology students will learn how to address security/privacy issues of processing/transmitting the collected information through hands-on experience.

Mobile networking and computing technologies have created strong demands and emerging appli-

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cations in multiple academic disciplines. Much research work has been done to explore applications for mobile technologies in health informatics. The research work encompasses the Internet [1], hand-held computers and PDAs [2, 3], and implantable wireless medical devices [4]. To address issues associated with mobile applications, research has been conducted on data confidentiality preservation [5], processed clinical data protection [6] and end-user competence study for protecting patients [7]. Our project combines these topics and provides a systematic overview from an educational perspective. Through collaboration between engineering and health sciences departments at WCU, this project introduces radical reform to the course Health Informatics via an interdisciplinary, application-orientated approach in conjunction with the course Wireless Communications and Systems. The team effort promotes applications of mobile computing technology in the areas of data acquisition, data mining/warehousing and security/privacy to both engineering and health sciences students. Consequently, an innovative model of mobile learning/application environment is created. Because health informatics addresses issues in health statistics and information administration where information comes from multiple sources, the project will have a broader impact on other pertinent fields such as athletic training, waste management, sanitary survey and administration and clinical information processing.

COURSE REDESIGN FOR INTERDISCIPLINARY WORKING

HIA 420, Health Care Informatics from our health science department will be redesigned to apply mobile technology in health information processing, administration and decision making. TEL 444 will be redesigned so that engineering students are inspired to learn wireless communications and networks theories in an application-orientated wireless environment. A series of joint instruction sessions and labs have been designed to achieve this goal. Table 1 shows the joint sessions of our approach.

There are six joint instructional sessions designed into this project. The course sessions are designed to maintain the integrity of the original courses. Without sacrificing the contents covered in the original curricula, these sessions tailor the applications into both health science and engineering courses. Each session occupies one standard class period, which typically lasts one hour and fifty minutes.

Sessions 1 and 2 aim at introducing general concepts to students from both disciplines. Session 1 can be scheduled in week two of a typical 15-week semester. From this session, health science and engineering students learn which specific areas in health informatics where mobile technologies can be applied. Session 2 can be scheduled in the third week of the semester. In a standard wireless communications syllabus, engineering students complete mathematics preamble in the first two weeks of the semester, and are introduced to existing and emerging technologies as a preamble to in-depth technical details in wireless communications and systems.

Session 3 may be scheduled in the sixth week of the semester when health science students start learning health information administration and management. At this time, engineering students typically have learned various modulations schemes for wireless transmission. They are prepared to understand data structures and formats for wireless communications.

Session 4 is offered in the eighth week when health science and engineering student teams can determine methods of collecting data and process acquired data into formats appropriate for health information professionals.

Sessions 5 and 6 are better offered towards the end of the semester, around eleventh and twelfth week. Generally, engineering students have learned wireless transmission channel characteristics and are ready to learn various wireless networks such as 802.11b/g. Study through session 5 will help students from both disciplines understand what needs to be protected through wireless transmission from a systems perspective. Session 6 offers general knowledge of encryption and security, which is of great importance to both engineering and healthcare professionals.

EXPERIMENTS FOR INTERDISCIPLINARY WORKING

To strengthen students' understanding of wireless technologies in healthcare information applications, three hands-on laboratory experiments are also designed in addition to the above joint instruc-

Table 1. Joint instruction sessions for interdisciplinary working

Session Number	Instructor's Department	Topics
1	Health Science	Health Informatics Overview—Current Applications of Mobile Technologies
2	Engineering	Mobile Applications Overview—Current and Emerging Technologies
3	Health Science	Health Information Management—Data Representation, Data Warehousing
4	Engineering	Techniques for Data Collection and Processing Using Mobile Technologies
5	Health Science	Health Information Security/Privacy—Sensitive vs. Non-Sensitive Information
6	Engineering	Data Encryption and Wireless Transmission Security

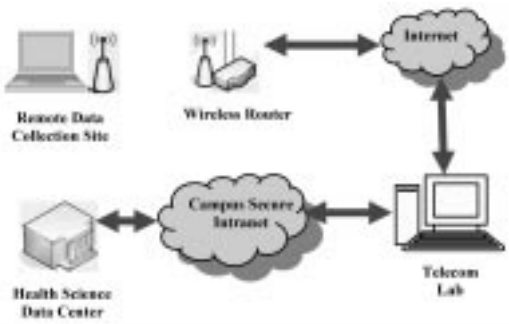

Fig. 1. Wireless data collection environment.

tional sessions. These labs are accomplished by engineering and health science student teams. Through these experiments, students are expected to:

(1) Learn team work skills—because students are from different disciplines, their ways of thinking and problem-solving may be different. Students will benefit from an interdisciplinary approach to finding optimal solutions.
(2) Compensate knowledge and skills—students possess different sets of knowledge and skills in two different areas of study. Through these experiments, students will learn how to combine and consolidate knowledge and skills to carry out interdisciplinary research,
(3) Strengthen their knowledge in data representation and warehousing, data collection and processing and information security/privacy.

Figure 1 shows the wireless data collection environment for our laboratory experiments design. A laptop is used for data collection and transmission. Different sensors are used depending on the data to be collected. The collected data are wirelessly transmitted to a wireless router that is connected to the Internet. The data are first collected by a dedicated network hosted in the engineering department's telecommunications laboratory. After preliminary processing, the data are collected by the university's health science department data centre via on-campus secure intranet.

In this environment, health science students and engineering students are expected to collaborate to address issues associated with database design, wireless transmission of data and information security.

The joint lab experiments for interdisciplinary approach are shown in Table 2. Data come from three different sources: Athletic Training (ATTR 383) for athletes' field training data such as pulse rates, Food Protection and Sanitation (ENVH 330), and Environmental Program Administration (ENVH 475) for data such as water quality parameters. Depending on the enrolment, three or six student teams will be formed, and one or two teams will be assigned to work with each of the three data sources.

In lab 1, students are required to design a mini-database where collected data will be categorized and stored. The purpose of this lab is to familiarize students with different data formats used for a specific type of health information, and the representation of sensitive and non-sensitive information. Students are required to use Excel to design the database. The main tasks include:

(a) design different fields to store various data for a complete personal health record;
(b) determine data format to be used for each field for feasible information retrieval/storage;
(c) determine appropriate data format for easy interface between data acquisition devices and laptop computers (and Excel);
(d) identify information sensitivity level for each field and determine if encoding or encryption should be used for information security.

The main role of health science students in this lab is to identify the types of data that need to be acquired to complete a health record, the format that these data should be stored in for easy analysis and retrieval, and to determine the sensitivity level of the collected data. Engineering students will help health science students determine the hardware and software interface, encoding method and encryption standard to achieve the desired data security level.

Lab 2 focuses on data monitoring and collection in the field, and wireless transmission of the collected information. Engineering students help setup the test sites and interfaces for data collection, and health sciences students are required to monitor the data collected by calling data into the designed Excel spreadsheet. Data monitoring should be performed real-time in the data collection fields to ensure data validity. After data collection, engineering students work with health sciences students to wirelessly transmit the information to the health science data centre via the university's 802.11b/g wireless network. Students should be instructed to delete the collected infor-

Table 2. Joint laboratory experiments for interdisciplinary working

Lab	Instructor's Department	Description
1	Engineering/Health Science	Mini-Database Creation—Data Format and Representation of Sensitive and Non-Sensitive Information
2	Engineering/Health Science	Data Monitoring, Collection, and Transmission Using Mobile Technologies
3	Engineering/Health Science	Information Security/Privacy Over Wireless Transmission Channels

mation from their laptop computers upon successful transmission of information to the data centre.

Lab 3 is designed to address security/privacy issues during wireless transmissions. There are two levels of security that need to be addressed. The first resides in wireless data collection, and the second is when data are transmitted through 802.11b/g network. To prevent nearby unauthorized wireless users collecting information in the test fields, object/user identification should be implemented. This can be accomplished by combining Radio Frequency Identification (RFID) technology with data acquisition devices. Data cannot be collected unless the user identification is verified. To address the second level security issue, sensitive information identified in Lab 1 should be encrypted before transmission. A further prevention measure can be taken by utilizing engineering Cisco networking lab to relay information to the data centre.

TECHNOLOGY INTEGRATION

Laptop computers with wireless cards provide a thread of continuity across the courses that are being linked in this project. Real life, hands-on, minds-on experience with mobile technology in the field and in the laboratory will overcome the barriers of uncertainty that impede broad implementation of the technology in the instructional delivery of these health science focused courses .Health science and engineering students work in teams to collect the data, to process data and transmit the data to the designated databases. They will come back to the classroom to access the databases and utilize the data for the targeted applications. Furthermore, the telecommunication engineering classroom focus will be problem solving and on improvements that more fully exploit the mobile technology. For instance, engineering department has a laboratory equipped with Cisco equipment that can be configured as an isolated network. To address the second level of security issues, engineering students can configure this laboratory as a data transmission relay. This network is the only one that is authorized to receive field data transmitted by laptop computers. Once the data are collected by this network, information can be accessed by authorized users through a secure pathway such as a Citrix platform which is also supported by the university.

CONCLUSIONS

The ultimate goal of this project is to build a model for an interdisciplinary, application-specific mobile learning environment that can be extended to multiple disciplines. Its objectives include, but are not limited to, creating a learning environment where engineering and technology students learn 'mobile technology within a mobile environment', developing an application-specific environment where health science students learn real-time data collection/processing using mobile technology, and nurturing students' capabilities of inventing application-specific technologies in multiple disciplines through team work. Major project outcomes are listed as follows:

(1) Data Collection—Proficiency in the skills and of direct field data acquisition to mobile platforms. Appreciate the barriers that exist for field data collection which can be overcome with mobile technology.
(2) Data Mining/Warehousing—For engineering and technology students: appreciate the flow down implication of the data collection methods on data analysis. For application students: experience techniques of creating/expanding databases with mobile data. For health data informatics students: accessing/processing real-time mobile data from data bases.
(3) Security/Privacy—Have an appreciation for the volatility of data in the wireless environment and the issues to be faced to maintain privacy and perform gate-keeping for client protection.

The pursuit of this project will be carried out in a project team format. The project goals of these cross-discipline teams will be selected such that a fully integrated process is achieved and demonstrated. Measurement of success will be determined by a review of the project by faculty, students and external participants including representatives from the application-specific areas.

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