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Work-in-Progress: Learning Embedded Smartphone Sensing technology On a Novel Strategy (LESSONS): A novel learning labware design, development and implementation

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I. Motivation

The exponentially evolved mobile devices and applications have played important roles in all aspects of our society[1]. In addition, the growth on hardware and software of embedded technologies has demonstrated their capabilities to influence the physical world via their complex functionalities[2]. Combining embedded system, wireless communication and mobile technology, remote sensing have shown significance on promoting better services in healthcare, environmental protection, and national security, etc. As its importance at the nexus of the future global economic competitions, these technology trends fuel the growing demand of well-trained workforce in mobile embedded system.

On the other hand, the embedded system has been demonstrated their capabilities to influence the physical world via complex functionalities instead of being a solely electronic device. Many universities realized its importance and have put efforts on promoting underlying courses in college-level education[3,4]. Due to its characteristic involving both hardware and software, embedded system is always listed as an essential course in both electrical engineering and computer sciences (or software engineering) curriculum. However, one main challenge in these major-oriented curricula is that students won't gain comprehensive knowledge in both hardware and software design by only taking one course in their major department. For example, students in EE major might learn materials focus on hardware design but lack of programming skill trainings. Rather, students in CS major might only learn microcontroller programming without hardware exploring. Thus, students can't be exposed to all cutting-edge technologies and can't gain strengths from both disciplines.

In addition, most engineering curricula required lab sections[5]. Students need to attend the physical laboratory section and to finish the specific project in the labs. They need to accomplish all pre-set lab activities in a limited time with many constrains and pressure. This instruction model jeopardizes students' learning effectiveness by reducing students' interests, blockading creative thinking, and hindering transformative innovations. Further, the training on the emerging mobile embedded systems education is even less and unavailable.

II. Portable labware design

In response to these dilemmas, we are working on developing a labware to be implemented in our embedded systems curriculum without further increase students' learning burdens. This labware is proposed and built based on our experiences on mobile learning environment[6].

Students can learn materials and work on lab activities anywhere/anytime[7]. The labware features of mobile embedded sensing systems design with student-center learning, multidisciplinary applications and sustainability characteristics. It is comprised of modules from introductory to ultimate system design modalities. The learning scheme is carried out through collaborative activities on building mobile embedded sensing systems with various environmental and biomedical applications. The inexpensive hands-on tools will assist students to acquire authentic experiences without physical lab setting. Throughout this labware training, students are expected to demonstrate their ability on building mobile applications, constructing embedded sensing systems, and performing remote sensing on different applications. The project will be hosted in a repository to ease the dissemination to the whole academic community.

We have developed the pilot modules in this labware. As an example, figure 1 shows the repository page of the prototype design. The labware is comprised of modules which are designed to be used from introductory of mobile device program to ultimate embedded sensor modalities. Currently there are six modules have been developed and each module contains three major components. The “pre-lab” is used to introduce concepts, background, and some activities for lab preparation. The “in-lab” activities provide instructions for students to hands-on required practices. The “post-lab” activities include student add-on labs and open-end projects. The labware will be delivery as an integrated package and deploy it on Google site to provide a “ready-to-adopt” model.

Fig. 1 Different modules of the labware for mobile embedded system engineering education

Within these six modules, module 6 “Android apps with external environmental sensors” is the module which students will work on the real-world relevant problem. The sensor platform is built by integrating an external dust sensor with microcontroller and communicate with an app on an Android based smartphone through a Bluetooth device. In this lab (module), students need to have comprehensive knowledge of how to make an Android app, how to use the wireless communication device in the phone to receive the signal from microcontroller, how to connect the dust sensor to the microcontroller and program it to acquire data from it. To avoid the high-cost financial burden, we adopted an off shelf dust sensors in this lab activity. The total cost of the whole platform is around $100. After completed the lab activity, in the “post-lab”, students can find the alternative sensors such as CO, CO_2, CH_4 gas sensor to replace dust sensor and further extend their knowledge in real-world relevant topics as well as increase their hands-on experiences. The figure 2 shows the components of the environmental sensor platform in this module activity.

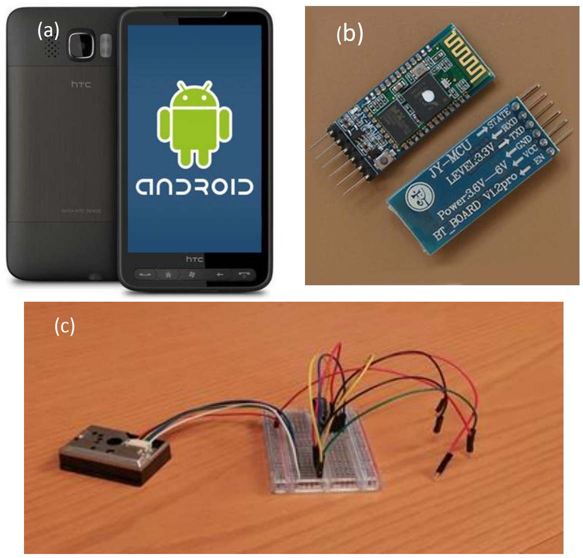

Fig. 2 Components of the environmental sensor platform show in module 6 activity. (a) Android phone. (b) Bluetooth external module to MCU. (c) Environmental dust sensor

III. Preliminary evaluation

The prototype of the labware (first 5 modules) has been demonstrated to be used on students who participated the NSF Peach State Louis Stokes Alliance for Minority Participation summer research sessions at SPSU for preliminary evaluation. Several students in this program worked on the project leaded by authors on mobile embedded system designs and developments and learned the materials through the prototype of the labware. In the end of the summer program, those students were requested to evaluate the efficacy of the labware to improve their learning efficiency and provided their feedback of the labware for further improvements.

Most feedbacks were positive and encouraging. Students were excited about the experiences of the new learning approach through modules in the labware and enjoy working on the real-world relevant problem with the android-based mobile sensing platform. They felt their learning efficiency dramatic improved on practicing the hands-on activities in the labware without limited time constrains as in the normal lab settings. In addition, they were able to seize any free-time opportunity to learn course materials through the mobile enabled labware in anywhere they liked. Finally, they were confident and motivated to work on more advanced topics and various applications in mobile sensing systems developments.

IV. Evaluation plan

With regards to evaluation of the leaning approach over the long term, we considered a comprehensive qualitative and quantitative evaluation plan to assess the project developments and progresses periodically; and gather evaluation results as on-going feedbacks from participants to improve the project in the future. All evaluation criteria are designed focus on the implementation progress, the effectiveness of the learning approach as well as learning materials and the facilitating faculty development under the new tool. All evaluations will be performed using standard testing instruments, surveys and interviews.

Qualitative Evaluation: the qualitative evaluations will be conducted to assess the effectiveness of the labware in terms of improving student learning and faculty participation in mobile learning education. Qualitative evaluations will document with surveys, interviews, case studies, and the analysis of evaluation data. One important assessment in this evaluation is the improvement of student knowledge in mobile embedded system design with/without assistant of our labware. A comparison analysis of the student instructional evaluations (SIR II) will be thoroughly examined to understand the impact on students' learning behavior with our labware.

Quantitative Evaluation: We will conduct quantitative evaluations which include the number of modules being developed, the number of examples in each hands-on practice, how many students involve in the learning approach, and more. Surveys on students in the class will be conducted by a Likert-type scale questionnaire (some survey questions in Table 1). This survey will help us on deeper understanding behavioral changes of students learning interests. We will also use quantitative evaluations to assess the learning outcomes, such as the average grades of exams, quiz and assignments, and students' satisfaction on labware design, pedagogy setting and the assessment method.

Table 1. Likert-type scale questionnaires for project participating students survey evaluation

Questions	Strong Agree Strong Disagree 5-----4-----3-----2-----1
I am interested in learning mobile embedded system design	○ ○ ○ ○ ○
I have previously learned how to design an embedded system	○ ○ ○ ○ ○
I am good at either hardware or software design on controlling embedded systems before this class	○ ○ ○ ○ ○
I like to use labware to learn class materials actively	○ ○ ○ ○ ○
I finished all the hands-on examples in each module and understand how to solve each question	○ ○ ○ ○ ○
I worked on the labware in anytime I want to learn it	○ ○ ○ ○ ○
I like the challenge of all hands-on questions	○ ○ ○ ○ ○
I learned more knowledge by working on this labware	○ ○ ○ ○ ○
I want to learn other different engineering courses with the method in this course	○ ○ ○ ○ ○

V. Project implementation

As the completion of the project, the labware will cover both basic and advanced mobile embedded system design topics including java programming, wireless local area network (WLAN) communication (i.e. WiFi, Blutooth), hardware (sensors, actuators) design, real-time software programing, and I/O interface. Thus, the labware is constituted by different modules which can be used as an integrated and sequential lab material to be implemented in a single embedded systems course or to be implemented as learning supplements for the specific course by employing the selected module in different engineering curriculum.

The authors are currently following the model curriculum of 2004 IEEE/ACM[8] and redesigning the curriculum in electrical engineering, computer engineering, and software engineering and gradually implement the developed labware to the related courses they offer. We are seeking longitudinal implementation strategy to maximize the influence of our labware to train our students. With this setting, we highly expect to drastically improve students' learning outcome and increases their proficiency in mobile embedded system design.

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