Use of Low-Cost Hardware in Human-Computer Interaction Classes across Mexico and Canada

Pedro C. Santana-Mancilla
School of Telematics
University of Colima
Mexico
psantana@ucol.mx

Laura S. Gaytan-Lugo
School of Mechanical and Electrical Engineering
University of Colima
Mexico
laura@ucol.mx

Miguel A. Garcia-Ruiz
Department of Mathematics and Computer Science
Algoma University
Canada
miguel.garcia@algomau.ca

Abstract
In this work, we present a proposal designed for teaching topics in a Human-Computer Interaction course using low-cost hardware to create prototypes and learn the required competencies of the field. This proposal has been applied in several projects in collaboration between the University of Colima in Mexico and Algoma University in Canada. These projects were created in order to improve different skills in students.

Author Keywords
Low-cost prototyping; HCI curricula; Technology adoption; Usability evaluation.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

Introduction
Human-Computer Human (HCI) courses often use the ACM SIGCHI curriculum as source [6]. But, as reported by [5], it should not be used directly in an individual university course. Rather, it should be applied as a comprehensive curriculum to train HCI specialists.

In the context of the University of Colima, the Bachelor's program of Software Engineering has only one HCI course. Therefore, it is necessary to use a project-based approach that gives students, not only knowledge of the basic principles of the area, but also knowledge on the different areas that converge in the HCI field. This project-based approach includes both theoretical and practical (hands-on) activities. This is why these students are asked to build medium-fidelity prototypes (including hardware when necessary).

Since 2012, a collaboration on several projects in the field of HCI and Serious Games with Algoma University started. As a result, from these collaborations, it was found that low-cost technology such as the Arduino UNO microcontroller and the Makey Makey digital interface can be effective to build functional prototypes. For the above reason, HCI students from Mexico and Canada have created low-cost prototypes in their HCI classes, which have let them practice and acquire knowledge through an experimental and experiential learning model utilizing these low-cost technologies.

The learning paths

This approach has been applied to several projects in both courses: a 5th-semester HCI course at the Bachelor of Software Engineering of University of Colima, Mexico. And, the 4th-year HCI course taught at the Bachelor of Computer Science of Algoma University, Canada.

Three case studies will expose how learners have acquired HCI competencies, designing, building and evaluating low-cost prototypes.

User Centered Design

To inform the prototypes design the User Centered Design (UCD) process was used. In a project carried on at the University of Colima, HCI students wanted to build a prototype of a smart classroom in order to improve the teaching and learning process. They designed a contextual study to know the opinions of the students from the University of Colima's School of Telematics. Their goal was to gather knowledge and opinions about what is it required to build a smart classroom.

As result of the study, it was found that the most desirable services for a smart classroom were: automatic control of lights and air conditioning, and turning on and off a data projector [1]. In order to implement these requirements, we envisioned that the smart classroom needed to address the following characteristics: support heterogeneous devices and ease of use [7].

To test the concept and fulfill the desired characteristics of the smart classroom, a prototype was created so students and teachers could interact and see if they achieved their goals with the prototype.

The prototype (see Figure 1) was developed using the Arduino UNO microcontroller as a central processing unit, wireless communication was provided with XBee transmitters. In addition, sensors provided information about the physical variables from the classroom (temperature, lighting, students' proximity), as well as an infrared transmitter for remote control of devices using infrared technology (projectors, air conditioners).

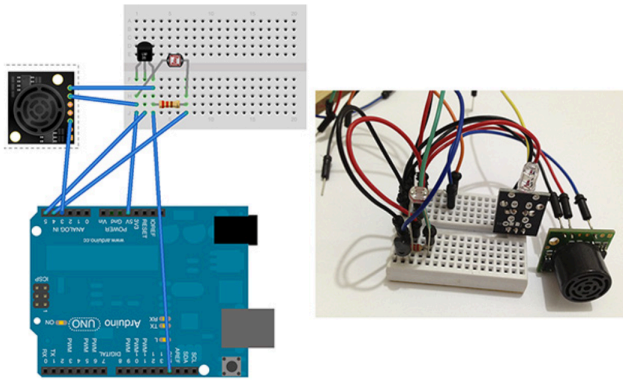

Figure 1: Prototype of a smart classroom using the Arduino UNO microcontroller, based on [1].

Measuring Technology Acceptance

The HCI course from Algoma University includes a class on user interface (UI) development. The UI topic is an important part of an HCI course, and should be taught with both theoretical and practical (hands-on) components and activities. In this UI development class, students need to learn and apply concepts on interactive UI design using specialized hardware and software for designing, developing and testing a UI.

In order to achieve the competences for UI development, students created an interactive video game controller using a low-cost hardware called Makey Makey [3] and used it with an online video game (see Figure 2).

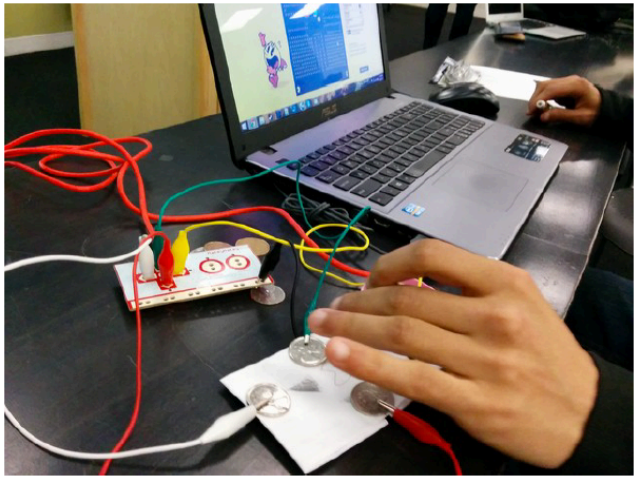

Figure 2: Prototype of a video game controller made with the Makey Makey and coins. Source [3].

To understand how users (students) accepted new technology (the Makey Makey) and to know if it was useful, the students learned about the Technology Acceptance Model (TAM) [2]. As result of the application of TAM to the project, it was found that all students perceived the Makey Makey as very useful and easy to use in the HCI class. In addition, many users expressed that the Makey Makey could be useful in further HCI classes.

Usability testing

To know how to conduct user studies of usability, students learned about the Think Aloud Protocol usability method and to apply the System Usability Scale (SUS) questionnaire at the end of the usability tests.

At the University of Algoma, a prototype that simulates wind in a racing video game was developed and tested. One of the research questions asked whether a low-cost technology could affect the usability of a racing game [4].

The prototype used two 12-cm. PC fans operated by an Arduino Uno microcontroller connected to a PC that was running a racing video game. A program written in Python controlled the fans' speed according to the car acceleration in the game (see Figure 3).

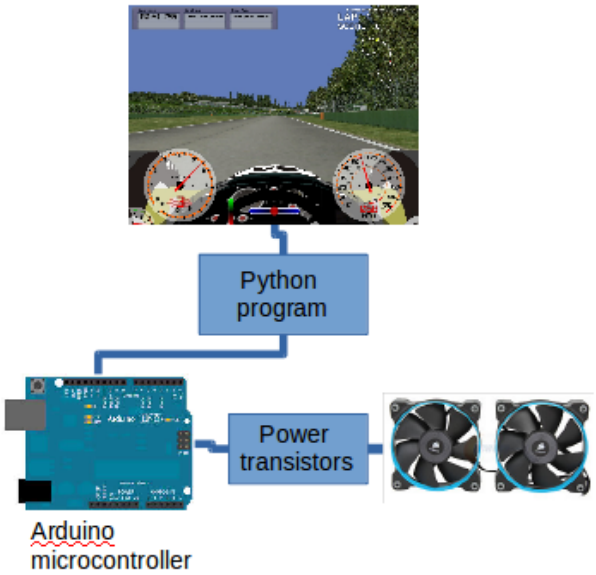

Figure 3: Prototype of a simulated wind using the Arduino UNO microcontroller. Source [4].

The task for users in the game was to drive in the car simulator for ten minutes, accelerating and decelerating every minute sequentially to perceive changes in the wind speed. Participants could perceive the simulated wind during those ten minutes. Results indicated that most of the participants (90%) felt the wind simulation was quite usable and non-obtrusive.

Conclusions

The use of low-cost material, like the Arduino UNO microcontroller and the Makey Makey, has brought HCI students a fun and practical way of acquiring HCI knowledge. This hardware can be easily integrated into HCI courses, since allows that students to create hands-on projects with technology in a very easy way. In addition, this technology can be afforded by schools with a limited budget.

Our goal in HCI Across Borders

What we expect from these symposium is not only to share our experience with the use of low-cost technologies such as the Makey Makey and the Arduino Uno, but also to gain knowledge through the feedback from other participants and researchers who also have experience or interest in the use of low-cost hardware in class. In addition, we will seek to establish academic contacts with people who are interested in the creation of a bigger cross-cultural study about using low-cost hardware in class.

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