proceedings **cd**

www.iated.org/inted2009

International Technology, Education and Development Conference

Valencia (Spain) 9th-11th March, 2009

INTED 2009

International Technology, Education and Development Conference
Valencia (Spain) 9th-11th March, 2009

conference **proceedings**

International Technology, Education and Development Conference
Valencia (Spain) 9th-11th March, 2009

INTED 2009

Published by
International Association of Technology, Education and Development (IATED)
www.iated.org

INTED2009 Proceedings CD

Edited by
L. Gómez Chova, D. Martí Belenguer, I. Candel Torres
International Association of Technology, Education and Development
IATED, Valencia, Spain

ISBN: 978-84-612-7578-6
Depósito Legal: V-662-2009

Book cover designed by J.L. Bernat Tomás

© All rights reserved.

Technical Program

INTED 2009 Sessions

Open Search

ORAL SESSIONS MONDAY

Session: Enhancing Learning and the Undergraduate Experience (1)
Session chair: Shelly Norris. University of Wyoming (UNITED STATES)

RUSSIA AND THE UNITED STATES: CROSS-CULTURAL COLLABORATION
S. Norris

THE USE OF MAILING LISTS ON THE INTERNET AS A COLLABORATIVE LEARNING VEHICLE IN A MARKETING CLASS IN JAPAN
T. Kimura

HEROES: TEXT AND HYPERTEXT: A MULTIMEDIA LEARNING EXPERIENCE
C. Griffin, O. Murphy

QUALITY ASSURANCE IN SOUTH AFRICAN HIGHER EDUCATION: WITH SPECIFIC REFERENCE TO WALTER SISULU UNIVERSITY (WSU) – EASTERN CAPE
A. Moodly, I. Saunderson

ENHANCING TEACHING EFFICACY BELIEFS AND ABILITY TO NOTICE OF PRESERVICE HIGH SCHOOL MATHEMATICS TEACHERS THROUGH A VIDEO CLUB
O. Alsawaie

MOTIVATION AND ATTENTION AMONG STUDENTS. SUCCESS CASES AND ACCUMULATED EXPERIENCES
A. Ruiz, T. Martinez

THE IMPACT OF EXTRINSIC FACTORS ON THE SUCCESS OF GROUP-BASED ASSIGNMENTS IN UNDERGRADUATE COURSES
G. Stock

Session: Technological Issues: E-Learning & Blended Learning
Session chair: Cristina De Castro. IEIIT-Italian National Research Council

HUMAN CAPITAL AND E-LEARNING. DEVELOPING KNOWLEDGE THROUGH VIRTUAL NETWORKS
M.E. Fabra, B. Forés

E-PBLEARNING: AN E-LEARNING FRAMEWORK USING PBL.
M. Samaka, S. Badr, N. Hadjazi, M. Al Abidi

AN E/M-LEARNING ARCHITECTURE BASED ON ALTERNATIVE STUDYING PATHS
C. De Castro

E-LEARNING @ ENTREPRENEURSHIP NEW HORIZONS IN BUSINESS MANAGEMENT
A. Kumar, S. Rajpal, A. Mittal

A QUALITATIVE STUDY ON EFFICIENT WEB-BOARD USE AS INTERACTIVE ASSESSMENT TOOL : A CASE STUDY OF EFL GRADUATE COURSE IN KOREA
S. Jeong, W. Jang

IMPLEMENTATION OF FEEDBACK MECHANISMS IN LEARNING SETTINGS USING A VIRTUAL COMMUNITY SYSTEM
L. Colazzo, A. Comai, F. Davi`, A. Molinari, N. Villa

Session: Experiences in Education: Transferring Disciplines & Competence Evaluation
Session chair: Richard Selby. Czech University of Life Sciences (CZECH REPUBLIC)

APPLIED COMPETENCE EVALUATION ; EFFICIENT ASSESSMENT TOOLS FOR AN OUTCOME-BASED APPROACH
N. Faucher, F. Vasseur

PROBLEMS OF ASSESSING LEARNING USING SIMULATIONS AND GAMES
D. Scott, S. Al-jibouri, G. Long, M. Mawdesley

COMPETENCE EVALUATION OF THE TEACHING STAFF WITHIN THE FRAMEWORK OF MILITARY HIGHER EDUCATION
I. Dinescu, O.-A. Pirnuta, I.M. Dinescu, M. Smeada

IMPLICATIONS OF PHILOSOPHY FOR ENGINEERING AND ENGINEERING TECHNOLOGY BACHELORS PROGRAMS
M. Dyrenfurth, M. Murphy, W. Grimson

INTERCULTURAL TEACHING
R. Selby

CHEMISTRY, THE HEALTHY INGREDIENT
C. Butchosa, A. Baltasar, S. Simon

A WEB-BASED E-LEARNING TOOL FOR THEORETICAL COMPUTER SCIENCE
E. del Acebo, I. Boada, J. Poch, F. Prados, J. Soler

AN IMAGINATIVE STORY AS A FACTOR OF ENGAGEMENT WITH AN EDUCATIONAL SITUATION AND AS A MEDIUM OF STIMULATION FOR CHILDREN'S CREATIVE IMAGINATION
M. Al-Ali

Session: Curriculum Design and Innovation (1)
Session chair: Nicolas Pallikarakis. University of Patras (GREECE)

CHANGES IN GLOBAL FOREST PRODUCTS INDUSTRY REQUIRE ACADEMIC CURRICULUM DEVELOPMENT
L. Hauhio, P. Lahti

DEFINITION OF THE EDUCATIONAL OUTCOMES OF FINAL YEAR PROJECTS
R. Fraile, I. Argüelles, J C. González de Sande, J M. Gutierrez Arriola, J I. Godino Llorente, L. Arriero Encinas, D. Osés del Campo, C. Benavente Peces

HARMONIZING THE CURRICULA OF BIOMEDICAL ENGINEERING PROGRAMS IN EUROPE: THE TEMPUS CRH-BME PROJECT
N. Pallikarakis, Z. Bliznakov

TECHNICAL MANAGERS' BODY OF KNOWLEDGE AND GRADUATE PROGRAMS' CURRICULUM: A CASE FROM THE UAE
S. El-Sayegh, H. El-Baz

WORKSHOPS/COURSES ON COLLABORATIVE LEARNING USING ICT
M. Ursic, H. Caf

USING A NEURO-FUZZY MODEL TO CALCULATE THE OPTIMAL RATIO BETWEEN DISCIPLINES FROM VARIOUS FIELDS FOR MECHATRONICS SPECIALIZATION
P. Schupp, W. Beck, O. Bologa, R.E. Breaz, G.S. Racz

TECHNOLOGY AND DESIGN, A NEW INTERDISCIPLINARY TOPIC IN NORWAY. WE GOT IN 2006 A NEW NATIONAL CURRICULUM, WHERE THIS TOPIC WAS INTRODUCED:
R. Baune

Session: University-Industry Collaboration
Session chair: Bob Barrett. American Public University (UNITED STATES)

ERASMUS PLACEMENTS PROGRAMME: OUR EXPERIENCE FROM UNIVERSITAT JAUME I OF CASTELLÓ
M.I. Beas Collado

M. Samaka, A. Abu Dyaa, R. Alashqar, B. Saeed, N. Al-Sada, N. Naser

MOBILE TECHNOLOGY: AN APPROACH TO EDUCATION SYSTEM
A.P. Tripathi

MULTIMEDIA-BASED METHODOLOGIES VERSUS TRADITIONAL PROBLEM SOLVING IN INTRODUCTORY PHYSICS
LL. Martínez-León, G. Mínguez-Vega, M. Fernández-Alonso, E. Tajahuerce, J. Lancis, V. Climent

PRESENTATION OF SPF: THE ON LINE LIFELONGLEARNING SYSTEM OF THE ITALIAN MINISTRY OF LABOUR
R. Gatti

PROJECTGRAMS AND DLXPLUS: VISUAL TOOLS FOR COMPUTER ARCHITECTURE AND ORGANIZATION EDUCATION
J. A. Reyes, P. I. Bautista, A. Cruz, A. C. Rio, M. Diaz, A. Lambino, C. Po

STUDENTS' PERCEPTION OF USING-BLOG-ON-TEACHING: A CASE STUDY IN THE DEPARTMENT OF JOURNALISM
H.W. Liu

THE APPRAISAL OF THE USE OF SOCIAL NETWORK PLATFORM FACEBOOK AS A SUPPORTIVE LEARNING TOOL FOR INFORMATION AND COMMUNICATION TECHNOLOGIES AND, AS A COLLABORATIVE EXPERIENCE FOR THE TURKISH STUDENTS
O. Tingoy, A. Duvenci, C. Aytekin, B. Degerli

THE RELATIONSHIP BETWEEN WORK PLACEMENT AND FINAL YEAR PROJECT. A PROPOSAL FOR ACTION TUTORIAL TO GUIDE THE STUDENTS IN THIS WORK
I. Sanz, M.D. Sanz-Berzosa, J. Mª. Torralba-Martínez

THE ROLE OF PORTFOLIO IN EUROPEAN HIGHER EDUCATION SYSTEM. A METHODOLOGY OF EVALUATION
Mª. D. Sanz-Berzosa, I. Sanz, J. Mª. Torralba-Martínez

THE "ARDILLA" PLATFORM FOR C/C++ PROGRAMMING PRACTICES
D. Ubeda, A. Gil, J.A. Lucas, L. Paya, O. Reinoso

TOWARDS A MORE SOCIAL DIGITAL LIBRARY
A. Sánchez, L. Iriarte, M. Marco, P. Pernías

USE OF SPREADSHEETS AS A PEDAGOGICAL POWERFUL TOOL FOR STUDENTS AUTOEVALUATION
J.R. Portela, I. de Ory Arriaga, E. Durán Guerrero

Session: Poster Session2. Research & International Projects & University-Industry Collaboration

A QUANTITATIVE STUDY EXAMINING THE QUALITY OF LIFE (QOL) AND HBA1C OF ADULTS WITH TYPE 1 DIABETES MELLITUS (T1DM); A DAFNE STUDY
L. Jeyes, E. Evans, P. Mansell, G. Adams

ANALYZING THE EFFECTIVE PLAN FOR PRODUCTION, TRANSMISSION , APPLICATION OF APPROPRIATE TECHNOLOGY FOR EXPLOITATION OF NATURAL RESOURCE " ON THE EXPORTER'S WORK OF DEPARTMENT OF FOREST OF IRAN"
M. Arfaee, M. Shariati

CLINICAL LEARNING IN POSTGRADUATE EDUCATION: A BLEACHING SYSTEM WITH OR WITHOUT LIGHT ACTIVATION
J. Oteo Calatayud, A. Oteo Zaccagnini, C. Oteo Calatayud, M.D. Oteo Calatayud

CLINICAL LEARNING IN UNDERGRADUATE DENTAL EDUCATION: A LIGHT AND HEAT ACTIVATED BLEACHING SYSTEM
J. Oteo Calatayud, H. Sawas, M.D. Oteo Calatayud, C. Oteo Calatayud

CONTINUING INTERCULTURAL PROFESSIONAL DEVELOPMENT IN EUROPE (CIPDE)
A. Britton, M.A. McMahon

DESIGN OF FUNCTIONAL FOODS: UNIVERSITY-INDUSTRY COLLABORATION PROJECTS

THE “ARDILLA” PLATFORM FOR C/C++ PROGRAMMING PRACTICES

David Úbeda, Arturo Gil, J.A. Lucas, Luis Payá, Óscar Reinoso
Miguel Hernández University
Elche/Spain
{ubeda |arturo.gil | lpaya | o.reinoso}@umh.es, jalucasmartinez@gmail.com

Abstract

In this paper a hardware and software platform is described. It allows the students of C/C++ programming subjects to carry out practical sessions, in which they are able to operate real devices. The practices are made remotely through Internet and offer the student the possibility to operate the equipment at our laboratory from their homes, in a flexible schedule, obtaining an unlimited access to the subject’s resources.

The system is motivated by the low interest shown by the students in C/C++ programming subjects. To date, the programming exercises do not seem to be stimulating for the students, and, as the year progresses, the attendance to practicals decreases approximately up to a 50%, causing the total number of students that manage to pass the subject to be as low as a 20%.

In order to change this situation, we focus on practicals with real microcontroller-based devices in which the student can observe the results of programming his algorithm in C/C++. We have observed that the students are more stimulated if they can see the results of their program working on a real device. Generally, the problem with this solution is that a large quantity of such real devices needs to be purchased and prepared for the practical sessions, needing a great initial investment and generating troubles.

In order to solve this situation, we have designed a hardware system that is based on the Arduino open hardware platform. The Arduino board can be programmed via an USB port, connected to a GNU/Linux server. The Arduino board communicates with different modules, actuating on electronic devices such as LEDs, DC motors and a LCD.

To date, the system has been working for a whole semester leading to an improve in the general results of the students.

Keywords

Innovation, education, C, C++, Arduino

1. Introduction

This paper presents an application that allows the students to program an Arduino microcontroller remotely. The application is intended to be used in C/C++ practicals by students.

The authors have been teaching C/C++ subjects in the first year in Industrial Engineering. These subjects have an important practical part, constituted by up to 45 hours of practical programming sessions. During the last years we have observed that practical sessions were not motivating for the students. This caused the decrease in the theoretical level in the lectures, and the necessity of repeating programming concepts several times. In consequence, the attendance to practical sessions dropped approximately a 50% as the final examinations approached. This causes that, with a great lack of experience in programming, most of the students failed in the final exam.

In our opinion, the main problem is related with the age of the students when they receive the C/C++ programming subjects in their first year in Industrial Engineering. In this sense, C and C++ concepts are completely new to them and imply a great change with respect to any other subject seen before. In addition, programming requires a great schematic vision of any problem, such as the implementation of algorithms or any application. Our experience says that this ability is very difficult to teach to the students. We normally find that the students desperately try compile and run any code without thinking.

In order to change this situation, the teachers involved in these subjects have tried to move towards an entirely practical approach. It is well known that students, specially in the first year, are far more encouraged when the subject has a practical orientation (probably, this habit is acquired during their secondary education). In consequence, we have focussed on practices with real devices in which the student can observe the results of programming his C/C++ algorithm physically. This solution was chosen since, apparently, the subjects that involve the use of microcontrollers do motivate the students, since they are able to interface temperature sensors, LDRs, LCDs and other devices that result attractive to them.

Once we found that we could motivate the interest of students by using this equipment, the problem consisted in translating the list of topics without interfering with other subjects where microcontrollers are taught.

We have chosen the Arduino computing platform [1] as the core of our system. The main reason for this is the existence of a vast user community where ideas, projects and solutions are exposed. Normally, we can find solutions to typical problems that appear when programming this platform. In addition, a great quantity of users publish their projects, along with their documentation. This fact further motivates the students and allows them to learn while they "play" with all the information and projects previously developed. In addition, Arduino is easy to use and to learn, since there exists a great number of tutorials and guides.

Finally, and considering the use of the Arduino platform in the practical lessons, we considered the problem of equipping every student with an Arduino platform and some sensors, LEDs, motors, etc… The problem with this solution is that a great quantity of such real devices needs to be purchased and prepared for the practical sessions, needing a large initial investment and generating the need of maintaining them in good conditions. In consequence, we propose a system that allows to control de access of a great number of students to a reduced number of Arduino-based modules.

2. System architecture

2.1 Arduino-based scale model

The architecture of the proposed system is based on the Arduino computing platform: an open architecture equipped with digital inputs and outputs which possesses a great flexibility and ease of programming. According to its developers, it is conceived to be used in the development of interactive autonomous devices. Currently, the Arduino platform is used by artists, educators, designers and hobbyists.

Arduino is able to sense the environment and execute actions consequently, such us, activating ligths, motors or other actuators. Moreover, it is cheap, open source and open hardware, so that it can be used to develop any project without the need of a license. This fact is of paramount importance in an educational application.

The motherboard relies on a single ATmega168 [2] microcontroller with an 8-bit RISC [3] architecture and 16 KB of programmable Flash memory. It provides 14 digital I/O, 6 out of them can be used to generate a PWM signal. Moreover, it possesses 6 analogical inputs with 10-bit A/D conversion. This fact allows to acquire information from the environment using sensors and actuate over any device using the outputs.

2.2 Server

All the architecture is placed in a minimum space. In order to do this, a 600x800x300 mm cube has been manufactured using aluminium profiles and methacrylate. A motherboard with an Intel Atom [4] processor @533 MHz has been used as server, which runs under Debian GNU/Linux [5] and an Apache2 [6] web server. We have developed an application that is used for the upload and administration of C/C++ code of the students. Using this application, the students are able to do the following tasks:

- Upload the code to the server.
- Compile the code and observe the results (i.e. compilation errors).
- Download the code from the server to any of the scale models governed by an Arduino board. Each scale model communicates with the server by means of a serial RS-232 [7] protocol using a USB port.
- Watch the results of their program real time, by means of a web cam.

The last part is performed using the software Motion [8], which is capable of real time video streaming and permits to store the videos, so that the students can save the results of their practicals. A set of scripts are used to associate each video to the student that is logged on the system at that moment. A general view of the system is showed on Fig. 1.

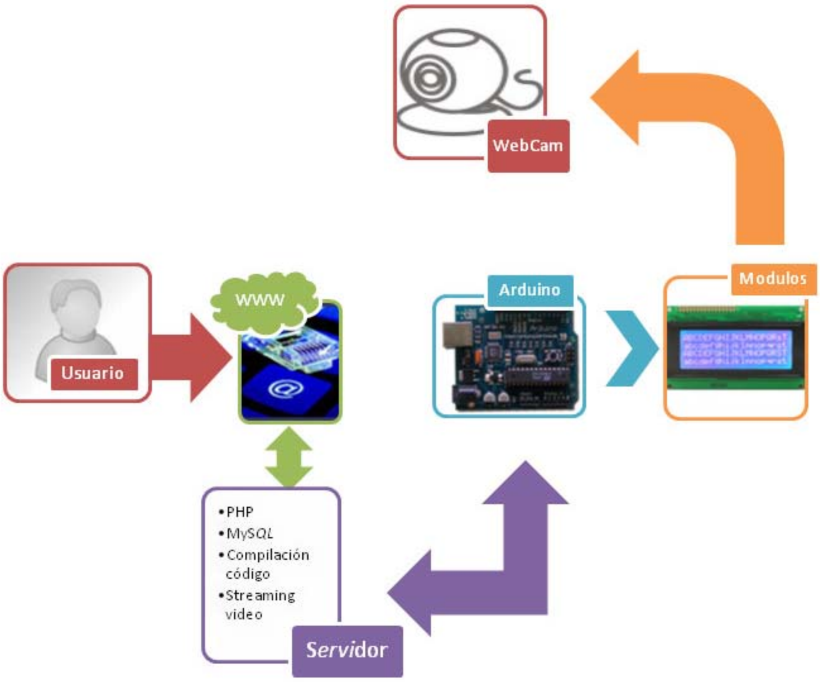

Fig. 1. General layout of the system.

2.3 Network architecture

As previously said, the communication of the server to the Arduino board is made via a serial RS-232 protocol with an USB port. The server is connected to the internet by means of a Fast Ethernet wired network.

2.4 Hardware design of modules and practicals

Arduino allows the connection of any kind of hardware to the board. In our case, the Arduino board is connected to two modules, where the sensors and actuators are connected. In the architecture presented here, the modules allow to observe the results of a program running on the Arduino board. The modules can be easily interchanged by others, and can be modified depending on the needs of each practical session or the concepts that are being taught at that moment.

The modules that have been developed consist of several hardware elements that can provide visual information to the student, such as LEDs, LCD displays or motors. This information is captured via a webcam and transmitted by video streaming to the web page.

Nowadays, two modules have been added:

- Module 1: Consists of a 20x4 LCD alphanumeric display and 6 LEDs with different colors.
- Module 2: Contains a 7 segment display, LEDs, a DC motor with reducer gear that can be driven in both directions and is equipped with an encoder. Additionally, there is a LDR illumination sensor.

ARDUINO	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MODULE 1	LED0	RS (4)	EN (6)	LCD(14)	LCD(13)	LCD(12)	LCD(11)	LED1	LED2	LED3	LED4	CHNN	TX	**RX**
MODULE 1	Green led	LIQUID CRISTAL DISPLAY CONNECTIONS							Red led	Yellow led	Green led	Channel selection bit	**Read/Write pins**	
MODULE 0	DP(7)	A (2)	B(15)	C (13)	D (11)	E (5)	F (3)	G (14)	M(+)	M(-)	LED5	**CHNN**	TX	**RX**
MODULE 0	**Green led**	**SEVEN SEGMENT DISPLAY CONNECTIONS**							**DC MOTOR CONNECTIONS**		**Red led**	**Channel selection bit**	**Read/Write pins**	

Fig. 2. Summary of the connections between the Arduino board and the modules.

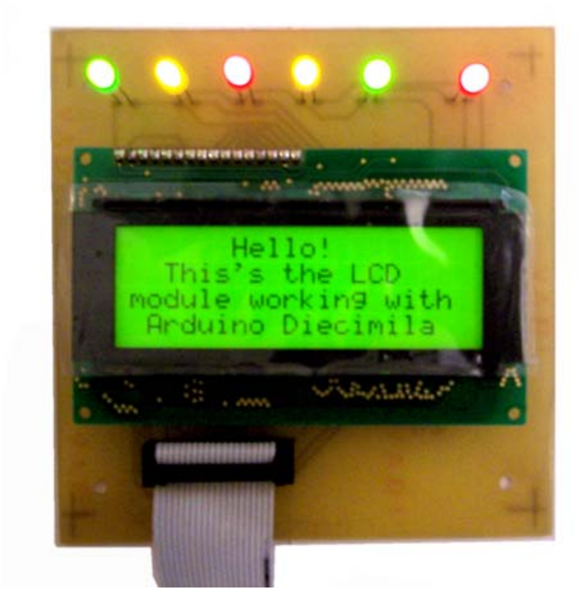

Fig. 3. LCD connected to module 1.

These two modules are connected to the Arduino board by means of a PCB that has been specially designed for the current project. This circuit is in charge of demultiplexing the digital I/O of the Arduino board. This circuit will be denoted as Module 0. As said previously, the Arduino has 14 digital I/O that suffice for most of the applications, but thanks to this circuitry we can use twice the number of the I/O of the Arduino board, that is, 28 digital I/O.
In this way, each one of the modules 1 or 2 is connected in parallel to the Arduino board, and we select each of the modules by means of a free digital I/O (1-bit). This module selection bit is controlled by software, meaning that, at any time, a program can give the instruction of changing from one module to the other, depending on the hardware to which we desire to communicate. For example, we may activate the motor that is connected to the module 0, then switch to module 1 and write on the LCD and state that the motor has been activated. Switching from one module to the other is made by a library function that changes the voltage level in the module selection bit (module 0). These connections are summed up in Fig. 2.

Connections between module 0 and modules 1 and 2 are made by means of 20 pin flat cable connections. All the pins can be easily accessed, so that any voltage can be manually checked, helping in this way the debugging of hardware design errors. In addition, the system can be easily expanded with new modules.

The modules that have been developed allow the student to develop a great number of programming functions. This surely helps the student to learn important programming concepts and clarify most ideas. The central core is formed by the LCD, that forms the main communication interface to exchange information with the student. The LCD is shown on figure 3. The LCD allows the student to debug programs, show data and variables. The LCD may be used to show in real time the data gathered from the sensors. For example, the illumination level acquired by the LDR sensor, the number of revolutions of the robot, the state of the LEDs. In addition, the LCD can be used to teach structures and working with matrices. The students are provided with the functions needed to initialize the LCD, write and delete characters, placing the cursor at a given position, etc… These functions are encoded in a library.

The DC motor (Fig. 4) can be used to program tasks in parallel and work with timers. For example, we can try to activate the motor and turn a given number of revolutions, or turn for a given number of seconds. Meanwhile, the direction of rotation can be showed by means of LEDs and the number of turns made can be placed in the 7 segments display.

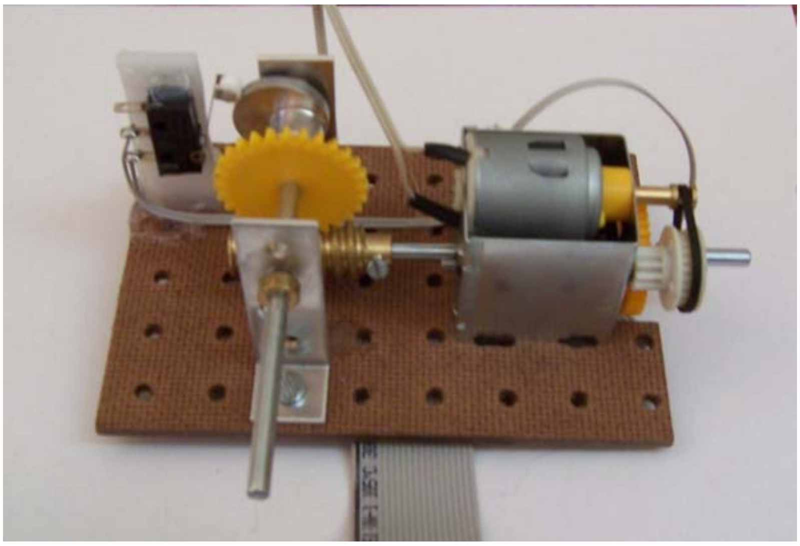

Fig. 4. Motor and reducer gear, connected to module 0.

Also, the LEDs are useful to debug programs. It can be used by the student to check the state of the program while it is being executed. For example, the LED1 could be switched on when exiting from a `while` loop, or when entering a special `switch` case. The state of the LDR can be read and then passed to a function in order to perform a mathematical operation with it. The 7 segment display can be understood as a set of LEDs. To work properly, the students may learn how to activate the LEDs correctly to display the information. The 7 segment display can be used to inform the user about the state of the program or showing numerical information or results (for example, the *i* counter in a `for` loop).

2.5 Web application

The web application has been programmed in PHP [9] and relies on a MySQL [10] database to store all the information about the practicals carried out by the students. In this way we can save the number of times that the student uploaded a program, compiled it, or downloaded and executed the program on an Arduino board.

Autenthication

Each student is given a username and password to enter the system, as shown on Fig. 5. We perform an access control based on sessions, that is, when the student is logged on the system he can use the system up to two hours. During this time, the student may upload the code to the server, compile it with the online compiler and, when no errors appear during the compilation, download the program to the microcontroller and observe the results. Once the session expires, the student must wait 24 hours in order to connect again to the system.

Fig. 5. Web server login page.

Online compiler

A PHP web module has been developed. It is based upon the GNU/Linux command line utilities for Atmel microcontrollers and the `avr-gcc` compiler [11]. The module shows the results of the compilation process to the student that is logged on the system. An example of the information produced by the compilation process is shown in Fig. 6.The errors produced by the compiler are presented on the screen, so that the student can read them and correct the program consequently. If there exist errors, the system allows the student to upload a corrected source code file. When no errors appear, an option is activated, so that the student can download the hexadecimal code to the microprocessor.
As a future work, we consider to highlight the information depending on the kind or errors presented. Also, a new interface will be developed. It will integrate the translation of the errors presented by the arv-gcc compiler, making them more readable. This function is specially interesting when the students start programming, since the compiler errors tend to be difficult to understand.

3. Off-line compiler and IDE environment

The Arduino board can also be programmed by means of a free license IDE. This environment is based on the Processing/Wiring projects. The Arduino IDE is available for several platforms (Microsoft Windows, GNU/Linux, Macintosh) and can be used to write applications in C/C++ with the set of instructions supported by the `avr-gcc` compiler.

The students can download and use the IDE environment at home. However, we consider that the arv-gcc compiler presents much more information about the compiling process, compared with the IDE environment. In addition, we consider that the web module is easy to use.

4. Library creation

We consider that the electronics in each need module to be transparent for the student. That is, the students do not need a deep understanding about the hardware. In order to do this, we have developed a set of functions that allow to easily interface the hardware. These functions are integrated in a library that will be integrated in each project. The student will be provided with these libraries, for example, to initialize, delete or write on the LCD.

In our opinion, these libraries are of great importance, since our system consists of different hardware devices that must be accessed using low level operations. However, the main objective is to teach C/C++ to the student, and not to deal with hardware problems. In consequence, the libraries allow to student to concentrate on C/C++ programming and interface the hardware without having to deal with it at low level, which may be difficult to understand by the students.

Fig. 6. Results of the compilation process.

5. Conclusion

The system has been working for a complete semester. During this period we have observed a some advantages, both for the students and teachers. In addition, we have observed some disadvantages, that we will try to fix in the future.

Next, we will list the main advantages provided by the system:

- A great advantage is the reduction in the infrastructure needed. There is no need of a great number of devices to be programmed by the students. In our case, only 3 Arduino boards suffice. The students can carry out their practicals at home, which is specially interesting to the ECTS credit system [12].
- Transparency of the electronics in the programming. This is particularly important for students who are not familiar with electronics. We think that this benefits the student, who may concentrate on the programming language instead of dealing with hardware details. For example, the student will be able to send the data to the LCD, but he must not be aware about the connections or the low level signals sent to the LCD.
- It is easy to repair the possible failures in the hardware modules. The modules are simple to connect and independent of each other. For example, the system can work even if one of the modules is not connected. It is possible to repair any failure by just interchanging a module for a new one.

- Since the system is modular, new functions can be easily added to the scale models, by adding new modules. This implies that new practical sessions can be designed without the needs of re-designing the whole system.
- The project considers an initial contact with the microcontrollers and their programming with high level languages. In this sense, the students does not need a deep understanding of the electronics in order to see real results on a real device. In this sense, we think that this aspect highly motivates the students, without having to deal with the low-level hardware details.
- In addition, correcting the practicals is pleasing, since the results are stored in videos that can be later viewed. This allows the teacher to observe whether the practical is correct or not, without having to observe the C/C++ code (which tends to be unpleasant).
- Finally, the system the hardware is protected against misuse, malicious use, or just programming errors that may cause failures.

The only disadvantage that we have found is the need of introducing the system to the students. Our experience says that the students need a whole practical session in order to learn the working of the system and learn all the features: authentication, online compiler, viewing the results, capturing the video, etc.

References

[1] Arduino home page, http://www.arduino.cc
[2] Atmel Microcontrollers, **http://www.atmel.com**
[3] Reduced Instruction Set Computer Architecture, http://en.wikipedia.org/wiki/Reduced_instruction_set_computer
[4] Intel Corporation, http://www.intel.com
[5] Debian GNU/Linux Distribution, Home Page, http://www.debian.org
[6] Apache Software Foundation, http://www.apache.org
[7] Electronics Industries Association, http://www.eia.org
[8] Motion detection software, http://www.lavrsen.dk/twiki/bin/view/Motion/WebHome
[9] PHP web scripting software, http://www.php.net
[10] MySQL open source database, http://www.mysql.com
[11] C runtime library for the AVR family of microcontrollers, http://savannah.nongnu.org/projects/avr-libc/
[12] ECTS, European Credits Transfer System, RD1125/2003 5th September “Establishment of European credits and qualifications system at Spanish university degrees”