Teaching Microprocessors Design Using FPGAs

Joaquín Olivares, José Manuel Palomares, José Manuel Soto, Juan Carlos Gámez
Dept. of Computer Architecture, Electronics, and Electronics Technology
University of Córdoba
Córdoba, Spain
olivares@uco.es

Abstract— **Microprocessors is a typical subject within the Computer Architecture field of scope. It is quite common to use simulators in practical sessions, due to the complexity of its contents. In this paper a new methodology based on practical sessions with real devices and chips is proposed. Simple designs of microprocessors are exposed to the students at the beginning, rising the complexity gradually toward a final design with a multiprocessor integrated in a single FPGA chip. Finally, assessment results are shown.**

Keywords: Learning Experiences; Laboratory Experiences; Teaching Engineering; Computer Architecture

I. INTRODUCTION

Traditional laboratory practical sessions to teach microprocessors are based on simulators, in this paper an experience implementing real microprocessors is shown. The main purpose is to encourage the student interest and to improve the assessment. This proposal is useful for many subjects within several engineering degrees. This activity was carried out in particular in the Microprocessors subject, in the degree in Computer Sciences at the University of Córdoba.

In most cases, computer architecture has been taught with software simulators [1], [2]. These simulators are useful to show: internal values in registers, memory accesses, cache fails, etc. However, the structure of the microprocessor is not visible, and students are not aware learning a real processor. Recently [3], [4], digital design is being teaching using real Programmable Logic Devices (PLD), showing it attractiveness for the students. Also recent works shown how the learning throw projects and games based on FPGAs are very useful [5].

In this work, a methodology for easy design and real implementation of microprocessors is proposed, in order to provide students with a user-friendly tool. Simple designs of microprocessors are exposed to the students at the beginning, rising the complexity gradually toward a final design with two processors integrated in an FPGA; each of which has an independent memory system, and are intercommunicated with a unidirectional serial channel. Furthermore, an introduction to the architecture of a T1 SUN OpenSparc system with 8 processors, 4 thread/processor plus one MicroBlaze is introduced at the end of the semester while students are working on their projects, this final seminar is useful because students are encouraged when see that a high performance parallel architecture is suitable of being implemented on a single FPGA Virtex5 [6].

In this paper the methodology to design and implement a microprocessor or multiprocesors is presented. To illustrate it with high detail and in a useful way, how to design the most complex practical session is shown. In section I, other methodologies based on simulators are referenced. The software platform used to implement real processors is presented in section II. Features of MicroBlaze processor are introduced in section III. The course practical content is described in section IV. To illustrate how a processor is designed and implemented, section V presents a brief guide of how to build a biprocessor, this is the most complex practical session. Finally, conclusions are presented in section VI.

II. SOFTWARE TOOL

The Xilinx Platform Studio (XPS) is used to design MicroBlaze processors. XPS is a graphical IDE for developing and debugging hardware and software. XPS simplifies the procedure to the users, allowing them to select, interconnect, and configure components of the final system. Dealing with this activity, the student learns to add processors and peripherals, to connect them through buses, to determine the processor memory extension and allocation, to define and connect internal and external ports, and to customize the configuration parameters of the components. Once the hardware platform is built, the students learn many concepts about the software layer, such as: assigning drivers to peripherals, including libraries, selecting the operative system (OS), defining processor and drivers parameters, assigning interruption drivers, establishing OS and libraries parameters.

Students have deeper documentation available in [7], [8], and other useful resources recommended are [9], and, [10].

An embedded system performed with XPS can be summarized as a conjunction of a Hardware Platform (HWP) and a Software Platform (SWP), each defined separately.

A. The Hardware Platform

The HWP is described in the Microprocessor Hardware Specification (MHS) file; it contains the description of the system architecture, the memory map and the configuration parameters. HWP can be defined as one or more processors connected to one or more peripherals through one or more buses. The definition of the activity follows this sequence:

- To add processors and peripherals.
- To connect them through buses.

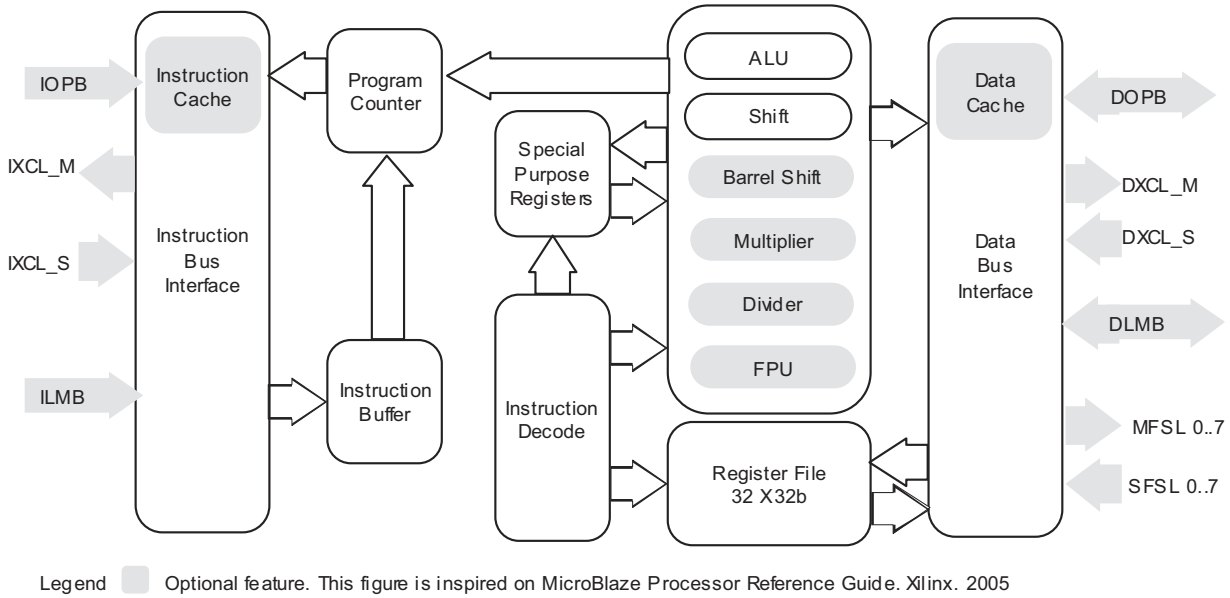

Figure 1. MicroBlaze architecture. In gray, reconfigurable components

- To determine the processor memory allocation.
- To define and connect internal and external ports.
- To customize the configuration parameters of the components.

B. The Software Platform

The SWP is described in the Microprocessor Software Specification (MSS) file; it contains the description of drivers, component libraries, configuration parameters, standard input/output devices, interruption routines and other software features. The sequence of activities needed to define the SWP is the following:

- To assign drivers to peripherals.
- To assign interruption drivers.
- To establish OS and libraries' parameters.

III. THE MICROBLAZE PROCESSOR

MicroBlaze is a 32-bit specific purpose processor developed by Xilinx in VHDL. It can be parameterized using XPS to obtain an *à-la-carte* processor. It is a RISC processor, structured as a Harvard architecture with separated data and instruction interfaces.

MicroBlaze components are divided into two main groups depending on their configurability as shown in Fig.1.

Some fixed feature components are:

- 32 general purpose registers sized 32-bit each.
- Instructions with 32 bits word-sized, with 3 operands and 2 addressing modes.
- 32 bits address bus.
- 3-stage Pipeline.

Some of the most important configurable options are:

- An interface with OPB (On-chip Peripheral Bus) data bus.
- An interface with OPB instruction bus.
- An interface with LMB (Local Memory Bus) data bus.
- An interface with LMB instruction bus.
- Instruction cache.
- To include EDK libraries.
- To select the operative system (OS).
- To define processor and drivers' parameters.
- Data cache.
- 8 Fast Simplex Link (FSL bus) Interfaces.
- CacheLink bus support.
- Hardware exception support.
- Floating Point Unit (FPU).

IV. PRACTICAL DESIGNS

Practical sessions introduce gradual learning, allowing the fast design based on previous sessions. Essential problems in hardware programming will be raised:

- Hyperterminal serial communication.
- Using IO ports.
- Memory controller.
- Interruption routines and priority.

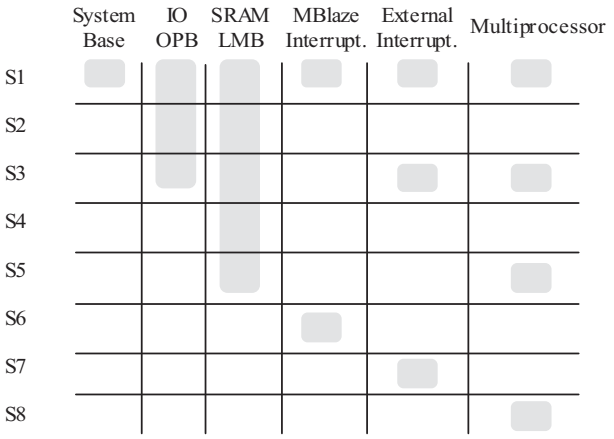

Figure 2. Sessions and contents.

- Message passing in multiprocessors communication.

The practical content of the subject is composed of 8 projects. In the first session, students make a basic system which will be used in following sessions as the base core system. Second and third sessions are used to introduce the input/output flow and the communication with external peripheral through the On-chip Peripheral Bus, for general purpose. SRAM external memory is added to the system at fourth session. Next session is dedicated to the External Memory Controller and how to split the bus. MicroBlaze interruptions are added in the sixth session, and external interruptions using the interruption controller are included in the seventh session. Finally, students build a biprocessor, using the Fast Simple Link channel at session eight. In fig. 2 the relation between practices is shown. For instance, 5th session is based on all previous sessions, 7th session is based on 3rd and 1st session.

V. BIPROCESSOR SYSTEM DESIGN

The last and most complex practical session is the design and implementation of a biprocessor. A computational system composed of two MicroBlazes will be designed. Both MicroBlazes will be interconnected using message-passing protocol. Each MicroBlaze has its own non-shared memory for instructions and data.

In the Fig. 3 a diagram with the structure of the design is shown. In it, the buses and components used have been detailed. It also includes how they are interconnected

At first, following the logical sequence exposed previously, a HWP will be created. This HWP will include the configuration of the components and buses, their interconnection, the memory map, ports and other parameters.

In the following subsection, the steps needed to configure the system will be described. Trivial stages, such as the creation of the project, will not be included in this paper. The parameters shown in this section depends on the FPGA chip, in this case the Spartan 3 board [11].

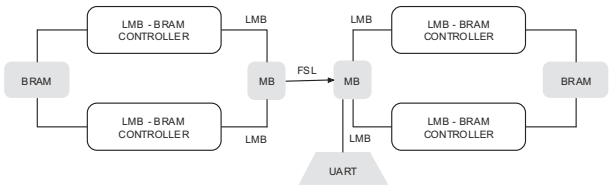

Figure 3. Biprocessor system diagram.

A. Hardware Platform Specifications

This stage is described in the MHS file. Following, the components specified in the structure of the system are enumerated:

- Two MicroBlaze processors.
- Two on-chip RAM memory blocks (BRAM), one for each processor.
- One UART.
- One OPB bus, to connect the UART with the slave processor.
- Two LMB buses to communicate each processor with their respective data memory controller; and another two LMB buses to interconnect the processors with their instruction memory controller.
- One FSL channel to intercommunicate each processor with the other.

After that, the interconnection of buses and components is defined. The connection of the memory ports are also set at this point. The student has to specify in the connection matrix which components are linked to which buses and with which kind of connection.

In the exposed case, four LMB buses are needed to access local memory, two for each MicroBlaze, because each processor has its own memory subsystem.

Also, one FSL channel which connects both processors.

Each BRAM has been designed with 4 different ports. Each MicroBlaze reaches its memory block through two different interfaces (instructions and data).

After that, it is necessary to map the components inside the configuration memory of the processors. XPS provides a functionality which is able to compute automatically a valid configuration memory map for a monoprocessor system structure. However, as the system proposed is a biprocessor one, this functionality cannot be used.

Each MicroBlaze looks for the first instruction in its program at memory address 0x0.

The next step is to define the internal and external ports. Most of the internal ones are configured by XPS with default settings. It is also necessary to define and to connect some of the internal ports to make the system works: those ports related to the reset and clock signals must be forwarded to all of the subsystems and components. Four external ports are mandatory: clock, reset, UART in and UART out. With these

ports, the student sends commands and synchronization information to the system. Finally, the components are configured. The parameters for each component and their meaning are described thoroughly in the documentation included in the XPS platform.

Particularly, MicroBlaze includes a parameter which selects the amount of FSL interfaces used. Thus, both processors have to set this configuration value to one to allow the communication between them. The configuration of this parameter is done by changing C_FSL_LINKS. This parameter has to be set to a numerical value, representing the amount of FSL interfaces to be included in the core.

Another interesting configuration to be mentioned is the UART operational configuration. The student has to determine the operational frequency, the application of the parity bit checking, working bauds, etc. A valid set of parameters for the UART and MicroBlaze are the following:

1) UART parameters.

a) C_CLK_FREQ = 50_000_000. Set the frequency of the OPB bus, connected to the UART. It has to coincide with the operational system speed.

b) C_BAUDRATE = 19200. Set the bauds for the UART. The terminal used to receive characters has to be configured at the same baud rate.

c) C_USE_PARITY = 0. Set whether the UART should work with parity bit or not.

2) MicroBlaze parameters.

a) C_FSL_LINKS = 1. In order to communicate between the two processors, at least, one FSL channel has to be defined.

After the HWP is defined, the netlist files and the support files can be generated.

B. Constraints File

The constraints file specifies how external ports from the designed system correspond with the Spartan-3 Board [ ] pins:

```
# Clock signal.
Net sys_clk LOC=T9;
Net sys_clk TNM_NET = sys_clk;
TIMESPEC TS_sys_clk = PERIOD
sys_clk 20000 ps;
# Reset button
Net sys_reset LOC=l14;
Net sys_reset TIG;
# UART
NET TX LOC = R13;
NET RX LOC = T13;
```

Once the constraint file and the HWP are ready, XPS has enough information to create the internal bitstream file.

C. Software Platform Specification

The SWP corresponds with the Microprocessor Software Specification (MSS). The first step is to select the drivers for the components, the SWP libraries and the OS for each processor. In this project, the standalone OS is selected, no libraries are used and the drivers for the components are established by default.

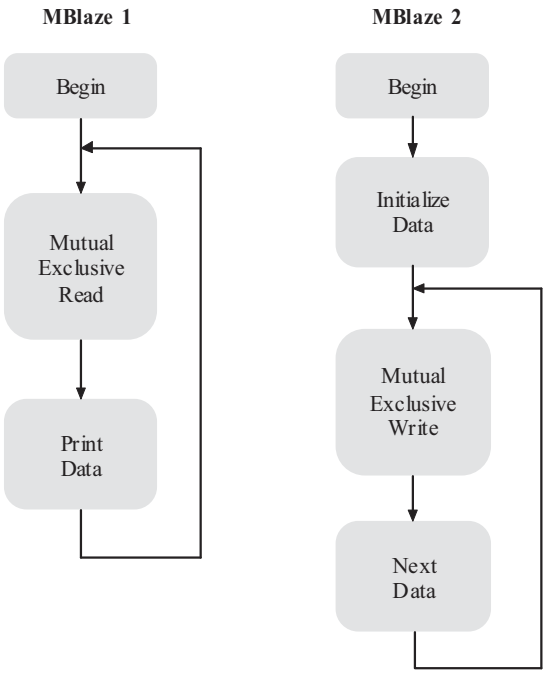

Figure 4. Software application flowchart.

In the following step, the configurable parameters from processors and drivers must be edited; also the interruption routines must be assigned if needed; for instance, in the system under explanation, the interruption routines are not used. In this case, all fields are configured by default except for the processors, which must be configured to work at 100 MHz.

In the final step, the OS libraries configuration parameters are edited and configured. The standalone OS has a minimum size software layer with some primitives for input/output, control, memory allocation, etc.

In the proposed system, the student must specify the UART as the input/output standard peripheral. This is established by assigning the UART to the OPB master MicroBlaze.

Once SWP is configured, it is possible to program the processors software code. However, it is necessary to generate previously the libraries and the Board Support Package (BSP).

D. Software Application

To carry out the goals of this work it is necessary to create two SW projects, one for each MicroBlaze. With these, each Microblaze will execute its own program.

Some primitives are used to allow a fluid message passing between both processors through the FSL channel.

The writer processor generates the data that will be sent to the reader processor through the FSL channel using mutual exclusion primitives for message passing. The OPB bus master sends the data received by the reader processor to the UART.

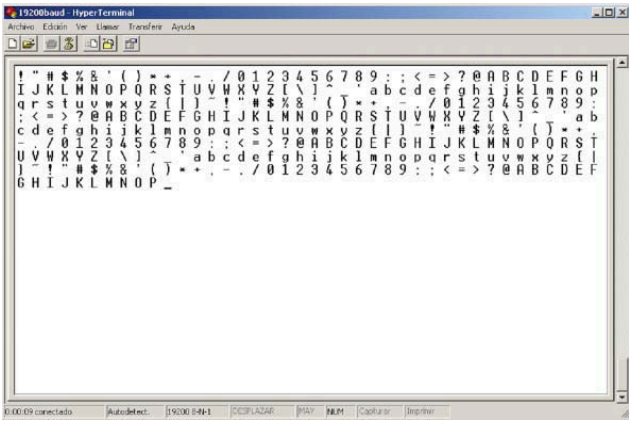

Figure 5. Hyperterminal capture while the both processors are i

After the compilation of the software application, the FPGA configuration file is generated.

Finally, the configuration file is loaded into the FPGA. After all these steps, the students execute the global system and they verify that both processors work properly: The reader processor reads data generated from the writer processor, and the writer processor generates successive data. This process is shown in Fig. 4.

Following the code based on C language for both MicroBlaze processors is shown. Some Xilinx libraries are required to optimize the code and to use some resources:

MicroBlaze 1 Code. Reading data from MicroBlaze 2 and showing them in the UART

```
#include <mb_interface.h>
int main( )
{
  int i;
  while(1) {
    microblaze_bread_datafsl(i,0);
    xil_printf("%c ",i); }
  return;
}
```

MicroBlaze 2 Code. Generating consecutive ascii characters and sending them to MicroBlaze 1 through FSL

```
#include <mb_interface.h>
int main()
{
  int i = 33;
  int c;
  while(1) {
    for(c=0;c<10000000;c++);
    for(c=0;c<10000000;c++);
    icroblaze_bwrite_datafsl(i,0);
    i++;
    if(i>126) i=33; }
  return;
}
```

Hyperterminal screen was captured and is shown in Fig. 5 to show the results when the both processors are running.

VI. Conclusions

XPS can be used as an excellent tool for the students to design and build complex architectures avoiding implementation details. Otherwise, they would spend a lot of time until they master concepts and techniques to develop those systems. Students understand the functionality and the structure of the different components, in order to interconnect all of them to build either a monoprocessor or a biprocessor.

A notable improvement of the qualifications compared to the average of the previous five years was obtained. In particular, in 2008 an improvement of 21% was obtained in front of the mean of the assessment for 2005-07 period. In 2009 the improvement in the assessment was 22%.

As a result of a survey, students are more motivated using real devices than using just simulators.

Furthermore, the configuration of each of the component parameters contributes to a better understanding of the developed architecture. And they are able to test how different values for those parameters influence the performance of the whole system. Finally, a guide on how to implement several processors systems on a single FPGA chip has been provided.

Acknowledgment

Authors wish to remark the great task carried out by the Xilinx University Program, XUP; and the Sun Microsystems OpenSPARC University Program, which have donated software and materials which have been very useful to partially finance this work.

References

[1] R. D. Williams, R. H. Klenke, and J.H. Aylor. “Teaching Computer Design Using Virtual Prototyping,” *IEEE Trans. on Education, vol. 46, no. 2, 296–301,* 2003.

[2] Simuproc. http://simuproc.softonic.com/ . Last accessed on 1st September 2009.

[3] T. Weng, Y. Zhu, and C.-K. Cheng. “Digital Design and Programmable Logic Boards: Do Students Actually Learn More?,” *in Proc. ASEE/IEEE Frontiers in Education Conference,* 2008.

[4] Y. Zhu, T. Weng, and C.-K. Cheng. “Enhancing Learning Effectiveness in Design Courses Through the Use of Programmable Logic Boards,” *IEEE Trans. on Education, vol. 52, no. 1, 151–156,* 2009.

[5] V. Sklyarov, and I. Skliarova. “Teaching Reconfigurable Systems: Methods, Tools, Tutorials, and Projects,” *IEEE Trans. on Education, vol. 48, no. 2, 290–300,* 2005.

[6] OpenSPARC http://www.opensparc.net/edu/university-program.html. Last accessed on 8th November 2009.

[7] -. “Platform Studio User Guide,” Application notes, Xilinx, 2005.

[8] -. “Microblaze Processor Reference Guide,” Application notes, Xilinx, 2005.

[9] -. “Embedded System Tools Reference Manual,” Application notes, Xilinx, 2008.

[10] -. “OS and Libraries Document Collection,” Xilinx, Application notes, September 2007.

[11] Spartan-3 Board. http://www.digilentinc.com/ . Last accessed on 30th October 2009.

Authors Index

Abbas, Ali 737
Abdelaoui, Nacer 1937
Abu aisheh, Akram 1425
Aedo, Ignacio 1931
Agea, Álvaro 1247
Agila Palacios, Martha V. 217
Aguado, Luis Angel 365
Aguiar, Javier M. 77
Ahmed, Ibrahimi 1801
Aledo, Angel 365
Alexander, Brad 997
Alimi, Adel 401
Allert, Heidrun 1597
Almeida Martínez, F.J. 1019
Alonso Atienza, Felipe 783, 1263
Alonso Fernández, F. 1181
Alorda, Bartomeu 653
Al Smadi, Mohammad 493
Álvarez Melcón, A. 1195
Álvarez, Miguel Angel 1493
Alvarez, Teresa 1541
Alvarez Vellisco, A. 237
Alves, Gustavo R. 1359
Al Zoubi, Abdullah Y. 1425
Amante García, Beatriz 1335, 1835
Anaya, Antonio R. 797
Andrés Gutiérrez, J. J. 1501
Angulo, Ignacio 327, 351
Anido Rifon, Luis 1683
Anterrieu, Eric 549
Antón, Miriam 1295, 1307
Añino, María Magdalena 1385
Aparicio, Francisco 1493
Aracil, Rafael 967
Aranzadi, Pedro 1039
Arcega Solsona, F. 99, 1173, 1441
Argüelles, Irina 929
Argyriou, Vasileios 743
Arias, Manuel 717, 1225, 1779
Ariol, Guillaume 1853
Arredondo, Belen 105
Arriaga, Jesús 129, 423, 1039
Arriero, Luis 929
Aschenbrenner, Andreas 943
Atienza, José M 807
Atif, Yacine 65
Auer, Michael E. 585, 1743
Aydin, Cansu Cigdem 593
Aydin, Elif 811
Baena, Carmen 1217
Bailey, Philip 145, 731
Baladrón, Carlos 77
Baldiris, Silvia Margarita 473
Baley, Philip 1409
Bárcena, Elena 1137
Bargstädt, Hans Joachim 639
Baron, Claude 1851
Barone, Dante A. 1147, 1521
Barrero, Federico 317
Barreto, Gilmar 1943
Baumann, Meter 523
Bellido, F.J. 1451
Bellido, Luis 1073
Belmekki, B. 1937
Beltrán de Heredia, Á. 1791
Benavente, César 929
Benito, Manuel 129
Benlloch Dualde, José V. 671
Besbes, Riadh 401
Bhave, Amit 1085
Blanco Galán, Marcos 1765
Blázquez Merino, Manuel 129, 423
Boada, Imma 973
Boehringer, David 1091
Bonache, Jorge 237
Borge, Marcela 1587
Borromeo, Susana 105
Bosch Estrada, José 937
Boticario, Jesús G. 797
Boto Giralda, Daniel 1307
Boukachour, Hadoum 725
Boulmalf, Mohammed 685
Bragós, Ramón 345, 1403
Braumann, Andreas 1085
Brito da Rocha, Claudio 647, 1057
Buendía, Félix 671
Bulkowski, Alexander 1667
Burguera, Antoni 653
Burkhart, Helmar 1075
Burr, Barbara 853
Cabral, José Manuel 159
Cabrera, Margarita 429, 1403
Cabrero Canosa, M. J. 863

Caeiro Rodríguez, M. 99, 869, 1173, 1441, 1683
Cagiltay, Nergiz 243, 811, 879, 1633
Callens, N. 1701
Calviño, Pablo 631
Camacho, David 1131
Camacho, José 539
Camacho, Michelle M. 839
Camara, José A. 631
Cancelas, José A. 1255
Candela, Santiago 601
Canete Rebenaque, David 1195
Cannella, Salvatore 769
Cano, Juan Carlos 671
Canovas, Alejandro 1273
Capdevilla, Ramón 1039
Carmona Flores, Manuel 937
Carmona, Cristóbal J. 983
Carpio, José 99, 1173, 1441
Carrasco, Juan M. 1165
Carrasco, Ramon 631
Carro, Belén 77
Carro, German 631
Carroll, John M. 1461, 1587
Carson, Stephen 1659
Carvalho, Adelson S. 1147
Casany, Maria José 1403
Casquero, Oskar 129
Castro, A. 1701
Castro, Manuel A. 99, 129, 327, 351, 357, 423, 569, 611, 631, 787, 819, 869, 907, 1137, 1171, 1407, 1441, 1731, 1829, 1869, 1909
Cedazo León, Raquel 1367
Chaiko, Yelena 695
Charlton, Terence James 179
Chatterjee, Arunangsu 897
Chavez, Igor 631
Chen, Chun Yu 575
Chen, John C. 381
Chicaiza, Janneth 129, 1111, 1513
Chuang, Sheng Hsiung 457
Ciampi, Melany 647, 1057
Ciancimino, Elena 769
Coble, Aaron R. 1085
Cobo Benita, José Ramón 701
Codreanu, Norocel 113
Coelho, Joao Vasco 81
Colmenar, Antonio 787
Colomer Farrarons, Jordi 321
Comber, Oswald 885
Conde, Carlos 631
Conejero, Alberto 231, 539
Corbalán, Montserrat 1869
Cordeiro, Joao 1283
Coronado, Sergio 199
Cortés, Francisco 317
Costa Freire, Joao 173
Costa, Helder 159
Costa, Monica 1283
Costa, Ricardo Jorge 1359
Costa, Rodrigo Garrett 407
Cota, Manuel Pérez 891
Cotfas, Daniel 585, 1641
Cotfas, Petra 585, 1641
Cousido, Carmen 237
Crespo, Raquel 1101, 1233, 1239
Crusafon, Carlota 833
Cuadrado, Félix 761
Cueva Carrión, S.P. 121
Cussó, Roser 833
Daniels, Mats 1051
Dávila, Luis 357
Day, Rally 953
de Armas, Valentín 1395
de Castro, Carlos 1295
de la Fuente, Luis 1101
de la Torre, Isabel 1295, 1307
de Vries, Pieter 1065
del Arco Fdez Cano, E. 1265
del Blanco, Ángel 1121
del Jesus, María José 983
Delgado Kloos, Carlos 303, 503, 1101, 1233, 1239, 1247
Delgado, José Luis 1137
DeLong, Kimberly 145, 1409
Derntl, Michael 1237
Devlin, Marie 179, 271
Dias, Octavio Páscoa 561
Dias, Pedro Miguel 1007
Díaz Lantada, Andres 1483

Díaz Orueta, Gabriel 1909
Díaz, Francisco Javier 1295
Díaz, Gabriel 99, 819, 907, 1173, 1441, 1731
Díaz, Pablo 1739
Díaz, Paloma 1931
Díaz Pernas, Francisco J. 1307
Díez, David 1931
Díez, José Fernando 1295, 1307
Dilhac, Jean Marie 1853
Domingo, Rosario 1859
Domínguez, Eugenio 1165
Domínguez, Manuel 99, 1173, 1441
Donnelly, Anne 1843
Dopico, Alberto 631
Dos Santos, Fabio R. 731
Drlik, Martin 1899
Drummond, Sarah 179
Duda, Andrzej 1667
Dueñas, Juan C. 761
Durán Escribano, Pilar 1649
Duran, Alfonso 1923
Echavarri Otero, Javier 1483
Elices, Manuel 807
Emmna, F. 1701
Enuma, Clara 1875
Eppes, Tom A. 845, 1425
Escovedo, Tatiana 1205
Exposito, Ernesto 1819
F. Linera, Francisco 1779
Fabregat, Ramón 473, 973
Faccioni Filho, Mauro 677
Falcone, Francisco 99, 1173, 1441
Falsetti, Carla 1527
Fayolle, Jacques 1937
Fernández, Pilar 755
Fernández Manjón, B. 775, 1121
Fernández Miaja, Pablo 1225
Fernández Mostaza, MªJ. 833
Fernández Panadero, C. 503
Fernández Nieto, G. M. 1289
Fernández Pantoja, Mario 329
Fernández Rodrigues, J.A 451
Fernao Pires, Vitor 561
Ferre, Manuel 967
Ferreira, André Luis A. 407
Figueiredo, António Dias 1317
Figueiredo, José 531
Figuera, Carlos 1265
Fitzgerald, Alan 389
Flores Arias, José Maria 1451
Florián Gaviria, Beatriz 473
Fontenla González, Jorge 869
Fontes, Ricardo 1283
Forward, Mary Lou 1659
Fourniols, Jean Yves 1853
Fraile, Ruben 929
Francisco, Jesús 1541
Franco Neto, Moacyr 677
Franquelo, Leopoldo G. 1165
Freudenthal, Eric 663, 991
Friesel, Anna 1327
Fritzson, Peter 1081
Fuhrmann, Thomas 313
Gadwal, Apeksha 287
Galán, Ramón 465
Galán, Santos 1711
Galeano, Katherine J. 211
Galeone, P. 1701
Galindo, Ernest 1493
Galinho, Thierry 725
Galkina, Alina 369
Gámez, Juan Carlos 1189
Ganoe, Craig 1587
Garbi Zutin, Danilo 1743
García, Ángel 967
García, Carmelo R. 601
García, Eduardo 1453
García, Enrique 1295
García, Miguel 1273
García, Pablo 1255
García Borrás, Patricia 465
García Campos, Rafael 91
García Doval, Fátima Mª 1785
García Martín, Javier 1575
García Pastor, Fabian 1751
García Robledo, Pablo 465
García Ruiz, Francisco 329
García Sánchez, Manuel 1299
García Sevilla, Francisco 1869
García Zubia, Javier 327, 351
Garofano, Francesc 345
Gay Fernández, José A. 1299
Ghercioiu, Marius 585
Gil, Charo 631, 1731
Gil, Marisa 833
Gil García, José Miguel 365
Gillet, Denis P. 897

Giraldo, Esmeralda 1923
Gironella, Xavier 1403
Glew, William 389
Godino Llorente, Juan I. 929
Göhner, Peter 853
Gomes, Marcelo Carboni 1521
Gomez Cama, José M. 937
Gómez Tornero, José L. 1195
Gómez, Iñigo Cuiñas 1299
Gómez, Isabel M. 1217
Gomis, Oriol 1401
González, Juan C. 929
Gonzalez, Julio Jorge 1875
González, María Jesús 1791
González, Miguel 1501
González, Oscar 543
González, Pedro 983
González, Victor M. 1255
González Aragón, M.l 1813
González Barahona, J. M. 1129
González García, S. 329
González González, C.S. 1479
González Lamar, Diego 223, 717, 1779
González Ortega, David 1307
González Téllez, Alberto 415
Gora, Wojtek 1893
Gorce, Philippe 401
Grabowski, Jens 943
Grande, Ana 543
Gravier, Christophe 1937
Gregorio, Robles 1129
Grieu, Jean 725
Guasch, Aleix 345
Guerreiro, Pedro 263
Guerrero, José 653
Guerrero Curieses, A. 783
Guetl, Christian 493, 731
Guevara Bolaños, Juan C. 1289, 1951
Guggisberg, Martin 1075
Guinea, Gustavo V 807
Günther, Markus 191
Gutiérrez Reina, Daniel 317
Gutiérrez Rojas, Israel 303, 1101, 1233, 1239
Gutiérrez, Juana M. 237, 929
Gutiérrez Pérez, David 1265
Gyalog, Tibor 1075
Hampe, Manfred 639
Hardison, James 145, 1409
Harward, Judson 145, 731, 1409
Hasna, Abdallah 1603
Heiß, Hans Ulrich 639
Heo, Jun Haeng 295
Hercog, Darko 959
Herms Berenguer, Atila 937
Hernández, Luis 967
Hernández, Roberto 611
Hernández, Rocael 611
Hernández, Unai 327, 351
Hernández, Filmar 237
Hernando, Marta 1779
Hernán Losada, Isidoro 1557
Herrero, David 1541
Hinojo, José María 317
Hoffmann, Michael H.W. 639
Horwath, Karla Chagas 1521
Hoyos Gomez, Guillermo 281
Huang, Hsin Hsiung 457
Huang, Jheng Yu 457
Huhtamäki, Jukka 137
Hvorecky, Jozef 1899
Ibáñez, Mª Blanca 1101
Iriguchi, Norio 153
Irurzun, Jaime 327, 351
Islam, Syed Zahidul 1159
Izu, Cruz 997
Jacobi, Jane 1843
Jara Roa, Dunia Inés 217
Jeschke, Sabina 825, 853,1893
Jezernik, Karen 959
Jiang, Hao 1587
Jiang, Jin 481
Jimenez Trillo, Juan 237
Jofre, Lluis 1761
Jongsawat, Nipat 1533
Jordá Albiñana, Begoña 1509
Jordana, Joséph 395
Juan, Jordi 231
Jucovschi, Constantin 523
Jurado, Francisco 99, 1173, 1441
Kalman, Tibor 943
Kamal Eddine, El Kadiri 1801
Kang, So Yeon 295
Kenyon, Tony 953
Khachadorian, Sevak 1065
Kicken, Wendy 819
Kiesling, Elmar 191
Kita, Toshihiro 153
Klein, Lawrence Zordam 677
Knipping, Lars 825

Kohse, Gordon 145
Komlenov, Zivana 885
Kondabathini, Vishal 751
Koper, Rob 1211
Köppel, Grit 825
Kraft, Markus 1087
Ktoridou, Despo 1807
Kubota, Shinichiro 153
Kunicina, Nadezhda 369, 695
Labrador, Manuel 237
Lach, Gerald 1893
Lafont Morgado, Pilar 1483
Lafuente, Guillermo 631
Lakas, Abderrahmane 685
Landaluce, Ariana 129
Lauer, Gerhard 943
Law, Effie L C. 897
Layton, Richard A. 839
Lázaro, Carlos 1557
Lecroq, Florence 725
Lee, Chyi Shyong 457
Lee, Joosung 295
Leo, Tommaso 1527
Leon, José I. 1165
Leony, Derick 1101, 1239
LI, Yamin 225
Lin, Shean Huei 575
Linan, M. 1451
Ling, Jonathan Geoffrey 389
Linsey, Julie 287
Llamas Nistal, Martín 99, 869, 1173, 1441
Llamosa Villalba, R. 1957
Lloret, Jaime 1273
López Campos, Mónica 769
López de Miguel, Manuel 937
López Zamarrón, Diego 1367
Lopez, Eugenio 631
López, Jorge 129, 1111, 1513
López, Miguel 1295, 1307
López Puche, Pilar 1575
Lord, Susan 381, 839
Lorente Leal, Alberto 451
Lorenzo, Emilio J. 1137
Lozano Tello, Adolfo 1765
Lübbe, Jan 1893
Luengas, Lely Adriana 211, 1951
Machado, Felipe 105
Machado, José 1277
Madeira, Rui Neves 561, 1013, 1673
Madrigal, David 1541
Magenheim, Johannes 513
Magoc, Tanja 991
Maier, Christian 1743
Maillet, Catherine 71
Maiti, Ananda 1351
Malpica, Norberto 105
Mandado, Enrique 755
Manganello, Flavio 1527
Manso, António 1007
Manzanares Bolea, R. 1419
Marchiori, Eugenio J. 1121
Marcos, Jorge 445
Mariño, José B. 1403
Marques, Célio 1007
Marquez, Juan J. 709
Marshall, Lindsay 179
Martín, Estefanía 1557
Martín, Sergio 569, 631, 787, 819, 1137
Martínez Bejarano, R. 1419
Martínez Mateo, Jesús 913
Martínez Muneta, M L. 709
Martínez, David 1791
Martínez, Oscar 1111
Martínez Calero, José D. 1869
Martínez Mediano, C. 819
Martínez Zarzuela, Mario 1307
Martinich, Leslie P 1551
Martins, Joao 561
Martins, Scheila Wesley 1317
Más, Jorge 231
Mateos, Verónica 1071
Matsuba, Ryuichi 153
Mayorga, José I. 1139
McIntyre, Michael 1715
Md Yusoff, Yuzainee 921
Medeiros, Claudia Bauzer 523
Medrano, Carlos 1869
Melo, Rubens 1205
Mena Mena, Alexis 281
Mendes, António José N. 1317
Méndez, Sergio 1957
Meriläinen, Joonas 137
Merkuryev, Yuri 1721
Mestres Sugrañes, Albert 429
Metrolho, José Carlos 1283
Meyer, Jörg 943
Miaja, Pablo F 717

Migita, Masahiro 153
Miguel, Paulo Victor O. 1943
Miilumäki, Thumas 137
Mikami, Akane 185
Milanovic, Ivana 845
Mileva, Nevena 819
Minguet, Jesús M. 907
Miribel Català, Pedro L. 321
Mißler, Rüdiger 205
Mitchell, John 953
Mitrofanov, Oleg 953
Mohamed, Azah 921
Mohamed, Khaldi 1801
Moncef BenKhélifa, M. 401
Monteiro, A. Caetano 1277
Montero, Eduardo 1791
Montero, Juan M 451
Montero, Susana 1931
Morales, Asunción 1395
Moreno Ger, Pablo 1121
Moreno Munoz, A. 1451
Morgado, Eduardo 1265
Morillas, Samuel 231, 539
Moss, Keith Edward 1883
Motschnig, Renate 885
Muhamad, Norhamidi 921
Mulder, Ingrid 1433
Müller, Florian 1075
Müller, Gerhard 639
Munk, Michal 1899
Muñoz Guijosa, Juan M. 1483
Muñoz García, Julio 1483
Muñoz Hernández, S. 913
Muñoz Merino, Pedro 1101
Muñoz Organero, Mario 1101
Muñoz Sanz, José Luis 1483
Muñoz, Javier 1739
Muñoz Fernández, Isabel 1575
Mur, Francisco 99, 1173, 1441
Murari, Carlos Alberto F 1943
Murillo, Gloria 631
Musashi, Yasuo 153
Mustapha, Ramlee 921
Nadeem, Danish 1211
Nagai, Takayuki 153
Najima, Daoudi 1693
Najjar, Jad 1239
Nakamura, Taichi 185
Nakano, Hiroshi 153, 165
Natho, Nicole Martina 825
Nawarecki, Edward 1667
Nelles, Wolfgang 513
Nesterova, Elena 487
Neumann, Susanne 1239
Niederstätter, Michael 1743
Nishihara, Akinori 1031
Nottis, Katharyn 381
Oberhuemer, Petra 1239
Ogrey, Alexandria N. 663
Ohland, Mathew W. 839
Olivares, Joaquín 1189
Oliveira, Joaquim 1153
Oliver, Joan 1343
Oliver, Sonia 1835
Omar, Mohd Zaidi 921
Ordieres Meré, Joaquín 701
Orduña, Pablo 327, 351
Ortiz Marcos, Isabel 701
Osés, David 929
Ostrovsky, Yakov 145
Pacios Álvarez, Antonia 701
Page, Helen 1701
Palmero, Javier 237
Palomares, José Manuel 1189
Pardo, Abelardo 1101, 1247
Paredero, Ruben A. 631
París Regueiro, MªT. 863
Parra, M. Pilar 1217
Pasman, Gert 1433
Pastor, Rafael 99, 611, 1173, 1441
Pastor, Vicente 1909
Patlins, Antons 695
Payeras, Magdalena 653
Pears, Arnold Neville 1051
Peire, Juan 569
Pelayo, Sofia 1277
Penn, Martin 389
Perassi, Marisol 1385
Pereda, José Antonio 543
Pérez Gutiérrez, Byron A. 281
Pérez López, Serafín A. 445
Pérez Molina, Clara 1139
Pérez, Jesús M. 709
Pérez, José Philippe 549
Pérez, Marimar 1403
Pérez Gama, Alfonso 281
Pérez Martínez, Jorge E. 1575
Pérez Rey, David 913
Pérez Rodriguez, Roberto 1683

Person,Patrick 725
Pescador, Fernando 129, 423
Petschik, Grit 825
Pfeiffer, Olivier Frédéric 1893
Phillips, Chris 271
Piedra, Nelson 129, 1111, 1513
Pierce McMahon, Joana 1649
Pinto, Enrique 967
Pires, Jorge Manuel 891
Pistoia, Antonio 1527
Plaza, Inmaculada 99, 1173, 1441, 1869
Poch, Jordi 973
Pohjolainen, Seppo 137
Polito, Catherine 1549
Ponsa, Pedro 1335, 1835
Pop, Adrian 1081
Porta, Marcela 71
Portillo, Ramon 1165
Pou Felix, Joséph 1869
Pousada Carballo, J.Mª 1785
Prados, Ferran 973
Premchaiswadi, Wichian 1533
Prince, Michael 381
Pueo, Basilio 1455
Puig i Bosch, Jordi 91
Pulido, Estrella 1131
Qian, Jinwu 225, 481
Quadt, Arnulf 943
Quesada Pereira, F. D. 1195
Quesada, Jerónimo 365, 1829
Quintáns, Camilo 445
Rachida, Ajhoun 1693
Ramírez, F. Javier 1859
Ramis, Jaume 653
Ramos, Daniel 1181
Raud, Zoja 1613
Read, Tim M. 611, 1137
Reis, Cristina 1277
Rela, Mário Zenha 1359
Renaud, Cyril 953
Requena Carrión, Jesús 783
Ressel, Wolfram 853
Rhode, Thomas 513
Ribickis, Leonids 369, 695
Richter, Christoph 1595
Richter, Thomas 1091
Rico, Mariano 1131
Rincón, David Andrés 211
Rings, Thomas 943
Rio, Miguel 953
RioPérez, Nuria 819
Rius, Juan Manuel 1403
Rivera, Adexe 601
Rocha, José Gerardo 159
Rodrigo, Covadonga 1137
Rodríguez Artacho, M. 217, 1137
Rodriguez Hernández, A. 621
Rodríguez Morales, G. 121
Rodríguez, Alberto 717, 1225, 1779
Rodríguez, Miguel 717, 1225
Rodríguez González, Ana 783
Rodriguez Losada, Diego 553
Rodríguez Navas, G 653
Rodríguez Santiago, N. 329
Rojas Sola, José Ignacio 1509
Rojko, Andreja 959
Romá, Miguel 1455
Romanovs, Andrejs 1721
Romans, Ed 953
Romero, Audrey 121, 1513
Romero, Carmen 1217, 1835
Romero, Cristóbal 983
Romero, Gregorio 709
Romo, Jesús 129
Ros, Salvador 611, 1137
Rosson, Mary Beth 1461
Ruiz, Elena 907
Ruiz, Jonathan 327
Ruiz de Garibay, J. 351
Sáenz, Mauricio 1041
Sagi Vela, Javier 1039
Sainz, Beatriz 1295
Sainz, José Antonio 365
Sainz de Abajo, Beatriz 1307
Salaverría, Angel 755
Sallier, René 205
Salvado, José 1153
Samoila, Cornel 585, 1641
San Cristóbal, Elio 327, 351, 357, 631, 819, 869, 1409
San Segundo, Pablo 553
Sanborn, Jennifer 845
Sánchez, Alicia 631
Sánchez, Antonio 77
Sànchez, Francesc J. 395
Sánchez, Francisco 99, 1173, 1441

Sánchez, Jaime 1041
Sánchez, José Ángel 99, 1441
Sánchez, Juan A. 1165
Sánchez Alejo, F.J. 1493
Sánchez Moreno, F.M. 1367
Sánchez Ortiz, José A. 1173
Sánchez Reillo, Raul 1419
Sánchez Terrones, B. 345
Sancho, Pilar 775
Santana, Iván 967
Sapena, Almanzor 539
Sarango Lapo, Celia P. 217
Savory, Seb 953
Schaper, Niclas 513
Scheel, Harald 1065
Schlicht, Wolfgang 853
Schmitt, Heike 639
Schröder, Christian 825
Schubert, Sigrid 513
Schütze, Andreas 205
Seabra, Eurico 1277
Sebastián y Zúñiga, J.M. 1367
Sebastián, Javier 717
Sebastián, Miguel Ángel 1813, 1859
Sebastián, Rafael 1829
Semmar, Yasser 685
Sendra, Sandra 1273
Sevaslidou, Maria 743
Sevilla Hurtado, Lorenzo 1813
Shih, Chien Chou 575
Shih, Yen Hua 575
Shuaib, Khaled 685
Sierra Alonso, Almudena 1575
Silius, Kirsi 137
Silva, Bruno 1011
Sim, Tze Ying 1565
Simões Piedade, Moisés 173
Simon, Bernd 1239
Sivianes, Francisco 1217
Smallbone, Andrew 1085
Soler, Joséph 973
Somacarrera, Maria Luisa 1923
Soshko, Oksana 1721
Soto Merino, Juan C. 253
Soto, José Manuel 1189
Souhaib, Aammou 1801
Stechert, Peer 513
Stefan, Alexandru 1641
Stefanou, Candice 381
Stolk, Jonathan 381
Stoyanov, Slavi 819, 1211
Stummer, Christian 191
Su, Juing Huei 457
Sugitani, Kenichi 153
Sustelo, Maria F. 263
Takashima, Akio 185
Tchoumatchenko, V.P. 1597
Tebest, Teemo 137
Tetour, Yvonne 1091
Thomsen, Benn 953
Thomsen, Christian 1065
Tirkeş, Güzin 593
Tobajas, Félix B. 1395
Tokdemir, Gul 243
Toledo, Ricardo 1343
Torabzadeh Tari, M. 1081
Toral Marín, Sergio L. 317
Torrente, Javier 1121
Totschnig, Michael 1239
Tovar, Edmundo 99, 129, 423, 1111, 1173, 1441, 1513, 1657
Tseng, Ya Fen 1391
Tungkasthan, Anucha 1533
Tzanova, Slavka 113, 819
Ubeda Mansilla, Paloma 1649
Ulloa, Ricardo 487
Urquiza Fuentes, Jaime 1019
Ursutiu, Doru 585, 1641
Usagawa, Tsuyoshi 153
Val, José Luis del 1753
Valderrama, Elena 1343
Valdiviezo Díaz, P.M. 217
Valencia, Manuel 1217
Vallejo, Enrique 1453
Vaquero, Joaquin 105
Vara, Alfonso 907
Vargas Berzosa, Carlos 429
Vargas Berzosa, F. 429
Vasileva, Tania Krumova 1597
Vázquez Alejos, Ana 1299
Vázquez Martínez, Juan 1419
Vazquez, Sergio 1165
Vegas, Angel 543
Velázquez Iturbide, Á. 1019
Velez, Javier 1137
Vendrell, Eduardo 231
Ventura, Sebastián 983
Ventura Traveset, J. 1701

Verd, Jaime 653
Vez Jeremías, José M. 1785
Viezens, Fred 943
Vilanova, Ramón 1335, 1835
Villagrá., Víctor 1071
Villena Román, Julio 503
Vinjarapu, Sai Krishna D. 751
Viswanathan, Vimal K. 287
Vodovozov, Valery 1613
Vogel Heuser, Birgit 1565
Waigandt, Diana M. 1385
Walker, Roger 1701
Wang, Tsung Li 1391
Wang, Xiaojing 225
Wannous, Muhammad 165
Watson, Roger 1085
Wenk, Bruno 435
Williams, Bill 531
Wilson, Stacy 1715
Winzker, Marco 375
Wyne, Mudasser F. 1623, 1921
Yaman, Seniz 1633
Zafeiriou, Stefanos 743
Zaharim, Azami 921
Zaman, Muhammad 1047
Zampunieris, Denis 199
Zaro, Milton Antônio 407, 1145
Zayas Gómez, David 1501
Zhao, Ling 481
Zhiravecka, Anastasija 695
Zimmermann, Martin 1773
Zorn, Erhard 825

Contributions Index

"*e-Adventure*" - Introducing Educational Games in the Learning Process	1121
A competitive collaborative learning experience in chemical plant design	1711
A computational introduction to STEM studies	663
A Concept Map Approach for Introduction to Computer Engineering Course Curriculum	243
A context for programming learning based on research communities	1317
A Knowledge based analytical model of propaedeutic cycles for Higher Education in Colombia: Linking Media Education to Higher Education in Colombia.	281
A Learning Approach Based on Robotics in Computer Science and Computer Engineering	1343
A Middleware for the Integration of Third-party Learning Tools in SOA-based Learning Management Systems	869
A New Competencies Assessment Data Model	473
A new Systemic Methodology for Lab Learning based on a Cooperative Learning Project	317
A Practical Electronic Instrumentation Course for Engineering Students	1181
A Project-Based Learning Approach to Teaching Power Electronics	717
A Project-Oriented Integral Curriculum on Electronics for Telecommunication Engineers	105
A Proposal for the Evaluation of Final Year Projects in a Competence-based Learning Framework	929
A Remote Laboratory to Promote the Interaction between University and Secondary Education	345
A review of electronic engineering design free software tools	1869
A simulation software for sequential control	553
A Student-Centered Collaborative Learning Environment for Developing Communication Skills in Engineering Education	783
A Study and a Proposal of a Collaborative and Competitive Learning Methodology	1011
A system to manage the alocation of MSc Dissertations at University of Minho	159
A Systems Theory Perspective of Electronics in Engineering Education	1829
A Tablet PC-Based Teaching Approach using Conceptual Maps	671
A technological platform for teaching control engineering	1147
A Tool to Reveal the Students Work Activity Along an Academic Period	1283
A Virtual Photovoltaic Power Systems Laboratory	1739
A web-based e-learning tool for UML class diagrams	973
Achieving and Sustaining Gender Balance in an Undergraduate Teaching Institution	845

Action Research: A Way to Generate New Approaches to Teaching Mathematics in Bioengineering 1385
Active Learning in Power Electronics 1451
Active Learning in Telecommunication Engineering: A case study 1557
Adaptation in a PoEML-based E-learning Platform 1683
Adapting the Telecommunication Engineering curriculum to the EEES: a project based learning tied to several subjects 1307
Adaptive Ecology M-Learning for National Park Based on Scaffolding Theory 575
Adaptive hypermedia systems for e-learning 1801
Adjunt Enterprise Professors in the European Higher Education Area 77
Aligning Assessment with Learning Outcomes in Outcome-based Education 1239
An adaptive Multi-Agent based Architecture for Engineering Education 217
An application-case for derivative learning: optimization in colour image filtering 539
An approach for Description of Open Educational Resources based on semantic technologies 1111
An enterprise e-learning solution: The UNED practical case in the EHEA 611
An Experience in Cooperative Learning Developing a Real Aerospacial Project 1225
An Experience of a Multidisciplinary Activity in a Biomedical Engineering Master Degree 321
An integrated system as a tool for complex technology learning 755
An Interdisciplinary Practical Course on the Application of Grid Computing 943
An Undergraduate Microwave and RF Low-Profile Laboratory 329
Analysis of the results of four years of research and application of a student-centered system based on the ECTS to first-year students in order to improve their performance in the subject AC-I 237
Analyzing self-reflection by Computer Science students to identify bad study habits 263
Applying a methodology for collaborative assesment in learning groups 1205
Applying an Inductive Method to a New, Multidiciplinary, Management of Innovation & Technology Course: Evidence from the University of Nicosia 1807
Approach to Teaching Communications Systems by Collaborative Learning. Student Perceptions in the application of Problem-Based Learning. 1295
Assessing Assessment Formats: The Current Picture 1233
Assessing Competency in Undergraduate Software Engineering Teams 271
Assessment of learning activities in discussion forums online 487
Assessment of the learning competence of mathematics for first-years of the Computer Science degree 231
Attracting Student Vocations into Engineering Careers. EnginyCAT: Catalonia Promotional and Prospective Plan 1761
Attracting, Retaining, and Preparing a Diverse Academic Engineering Workforce 1843

Authoring Environment for E-learning Production Based on Independent XML Formats 415
Authoring Learning Contents, Assessments and Outcomes in an Integrated Way 303
Automatic Guidance Tools for Enhancing the Educative Experience in Non-Immersive Virtual Worlds Preliminary results from project V-LeaF 1131
Bringing the everyday life into engineering education 1433
Business and Management Competency of Engineers: Curriculum and Assessment 295
Challenges in an Emerging Country: A Digital Divide Case Using Robotics 1521
Challenging Students' Responsibility: An Engagement Methodology 253
Collaborative Subjects for Embedded Systems Learning in the EHEA Frame: A Practical Approach 1255
Competence certification as a driver for professional development: A IT-related exploratory case-study 81
Competencies for Informatics Systems and Modeling. Results of Qualitative Content Analysis of Expert Interviews 513
Competency-Based Pedagogical Wrapping 65
Computation for Science and Engineering 991
Consequences of the Declining Interest in Engineering Studies in Europe 71
Continuous Proactivity in Learning Management Systems 199
Cooperative assessment in the hands on skills of computer networks subjects 1273
Cooperative Learning vs. Project Based Learning: a practical case 1575
Cooperative work and continuous assessment in an Electronic Systems laboratory course in a Telecommunication Engineering degree 395
Course design approaches for the EHEA. Scaling up from pilots. 1923
Current Issues With Assessment Formats and Interoperability 1247
Cybertech: Robotic Competition and Subject 465
Database Teaching tools 1883
Deep Drawing Tool for E-learning 1859
Delievering authentic experiences for engineering students and professionals through e-labs 1085
Deployment of Remote Experiments: The OnPReX course at the TU Berlin 1065
Design lab work in telecom 1853
Design of an Educational Oscilloscope 1875
Design of an Introductory Networking subject in advance of the European Higher Education Area: Challenges, experiences and open issues 1453
Developing an Optical Spectrum Analyzer 313
Developing and Evaluating a Game-Based Project Management Learning Platform 1391
Developing Global Teamwork Skills: The Runestone Project 1051
Development of a mobile learning framework for analog electronics course 561

Development of a Small Radio Telescope at the Technical University of Cartagena 1197
Development of a Wiimote-based gesture recognizer in a microprocessor laboratory course 451
Development of the OCW Consortium 1659
Developping of Low Cost Capacitive Sensors for Laboratory Classes 445
Didactic videos about basic concepts on alternating current circuits 1941
Directions in Quality
Distance Practices in Subjects of Automatic Control 967
Distributed Collaborative Homeworks: Learning Activity Management and Technology Suppor 1587
Dual Instructional Support Materials for introductory object-oriented programming: classes vs. objects 1931
Dynamic Virtual Environment for multiple Physics Experiments in Higher Education 731
Easily Integrable platform for the deployment of a remote laboratory for microcontrollers 327
Educational Computer Tool for Visualizing and Understanding the Interaction of Electromagnetic Waves with Metamaterials 543
Educational Research in Spain: A review through the Education Awards of CESEI - IEEE 99
Educational Software Interface for Power Electronic Applications 1165
Educational visualizations of syntax error recovery 1019
Educative use of simulators in free software for the education of the physics in the engineering programs 621
Efectiveness of a Peer Mentoring Program in Engineering Education 1395
Embedding Sustainability in Capstone Engineering Design Projects 1603
Encouraging Interaction and Status Awareness in Undergraduate Software Engineering Projects 179
Engaging Weaker Programmers in Problem Solving 997
Engineering Education in the Developing World: Complexity and Sustainability 1047
Engineering in Latin America: A view at the Higher Education Level 1039
Engineering societies as a vehicle tool for engineering students. 631
Engineers and their practice: a case study 531
enginy@eps: Motivating the Engineering Courses 653
Enhance Learning System by using Real-time Internet Classroom and Web-based Collaborative Works 1533
Enhancing Authoring, Modelling and Collaboration in E-learning environments: UNED research outline in the context of E-Madrid excellence network 1137
Enhancing Database Querying Skills by Choosing a More Appropriate Interface 1899
Ensure Program Quality: Assessment A Necessity 1623

ESA Hands-on Space Education Project Activities for University Students: Attracting and Training the Next Generation of Space Engineers 1701
Evolutionary algorithms for subgroup discovery applied to e-learning data 983
Evolutive Mechanism for E-Learning Platforms - A new approach for old methods 891
Experiences in using a MUVE for enhancing motivation in engineering education 775
Experiences in Using Integrated Multimedia Streaming Services to Support E-Learning in Manufacturing Processes 1773
Experiments in evaluation: towards an eXtreme Learning method 761
Federated authentication and authorization for reusable learning objects 1071
Filling the gap of Information Security Management inside ITIL®: proposals for posgraduate students 907
Fingerprint Identification in LMS and its Empirical Analysis of Engineer Students' Views 1731
FPGA/Embedded system Training Kit Targeted to graduate Courses towards Industry level short training 1159
Game-based learning in technology management education 191
GE3D: a virtual campus for a technology-enhanced learning 725
Generalization of an Active Electronic Notebook for Teaching Multiple Programming Languages 1081
GILABVIR: Virtual Laboratories and Remote Laboratories in Engineering. 1403
Hands-on intelligent mobile robot laboratory with support from the industry 457
Hardware Implementation of Remote Laboratory for Digital Electronics 357
Higher Education Process Management Model, Educative Programs Improvement in Software Quality 1957
How can Apache help to teach and learn automatic control? 1541
Illustrating amazing effects of optics with the computer 549
Impact of Learning Experiencies Using LEGO Mindstorms® in Engineering Courses 503
Implantation of a Methodology based on Standard Supplements applied in Engineering Education 1813
Implementation of a virtual communications laboratory for e-Learning 1425
Implementation of An Engineering Educator Graduation Program for the formation of New Skilled Engineering Teachers 647
Implementing new learning methodologies in the Hard Sciences: a cross curricular study of students' and professors acceptance 1835
Indexing and Searching Learning Objects in a Peer-to-Peer Network 1667
Influence of Libre Software in Education The blogs planet case 1127
Influence of PBL Practical Classes in Microcontroller-Based Digital Systems Learning 1779
Information Technology in Logistics: Teaching Experiences, Infrastructure and Technologies 1721

Innovative Learning and Teaching Methodology in Electronic Technology Area. A Case Study in Computer Science University Degrees 1217
Innovative Practices for Learning Human-Computer Interaction by Engineering Learners 1041
Integrating digital video resources in teaching e-learning engineering courses 1791
Integrating People and Technology By Design: Design-First Instruction for Introductory Students in Information Technology 1461
Integrating Teams In Multidisciplinary Project Based Learning in Mechanical Engineering 709
Integrating the Design Thinking into the UCD's methodology 1479
Integration View of Web Labs and Learning Management Systems 1409
Intelligent evaluation in educational context 401
Internet-based Performance-centered Learning Environment for Curriculum Support (IPLECS) and its application in mLearning 819
Interoperable Content for Performance in a Competency-driven Society: Results from the iCoper project
Introducing alternative assessment into engineering language education at the Madrid Technical University 1649
Introducing multidisciplinary thinking in Computer Engineering - A new way of teaching database systems 523
Introducing Project Management Theory into a Capstone Design Sequence 1715
Introducing Scenario Based Learning: Experiences from an undergraduate electronic and electrical engineering course. 953
Introduction to Electronics as a Minor Subject 375
Knowledge Management and organizational learning University-Company - Learn to Learn- 1289
Knowledge Management and Professional Profiles in Electronic Systems Engineering 365
Knowledge, skills, and competences -- Descriptors for Engineering Education 639

Lab2go - A Repository to Locate Educational Online Laboratories 1743
Learning by doing in Project Management: Acquiring skills through a collaborative model 701
Learning Dynamics and Control in a Virtual World 737
Learning engineering by teaching engineering in the European Higher Education Area 1455
Learning network protocols through WSN based games 937
LMS and Web 2.0 Tools for e-Learning: University of Deusto´s Experience.Taking Advantage of Both 1753
M2Learn: Towards a homogeneous vision of advanced mobile learning development 569
Madar learning : learning envirnment for E&M learning 1693
Management and Optimal Distribution of Large Student Numbers 1893

Meaningful learning checking of concepts related to equations and functions in Physics Chemistry according to the main theme gas laws. 407
Measuring collaboration and creativity skills through rubrics 1513
Mechatronics E-course for regular students and adults: realization and comparison of efficiency 959
Meta-analysis of the TAEE project applying social network analysis 129
Methods of the quality assurance applied at remote laboratory selection 1641
Mixed e-Assessment: an application of the student-generated questions technique 769
M-learning tools on distance education 677
Model of Virtual Laboratory 1951
MotionLab 1501
Motivating Younger Students by Using Engineering Graduation Projects to Facilitate their Work 1153
Nano-World A Showcase Suite for Technology-Enhanced Learning 1075
Natural Sciences in the Information Society - First Experiences 825
NETLAB: Online Laboratory Management System 1341
New Directions in Engineering Accreditation 1921
OCW Consortium: learning through the worldwide sharing and use of free, open, high-quality education materials organized as courses 1657
OER´s production cycle with social authorship and semantic tools 121
On Education Quality Control Issues for Sino-France Hybrid Engineer Diploma 481
On Freshman Training of Engineering Students by Projects and DIY Activities 225
Online assessment of practical knowledge in electronics laboratory 751
Open educational resources (OER) inspire teachers and motivate students 435
Open Source Learning Management Systems in E-Learning and Moodle 593
Paper-Based versus Computer-Based Testing in Engineering Education 1633
Personal Learning Environments in a Global Higher Engineering Education Web 2.0 realm 897
Personalized Construction of Self-Evaluation Tests 863
Platform for teaching of location technologies based on Zigbee Wireless Sensor Networks by learning-through-play theory 1299
Portugol IDE v3.x 1007
Practical Framework of Employability Skills for Engineering Graduate in Malaysia 921
Practice and Research in Engineering Education: Activities of the CESEI Technical Committee 1173
Principles for the Design of a Remote Laboratory 879
Project-Based Collaborative Learning of Electrical Master Students 1613
Public Displays and Mobile Devices in an Augmented Objects Framework for Ubiquitous Learning 1673

Ranking Learner Collaboration according to their Interactions 797
Real Projects to involve undergraduate students in CS degrees 833
Reconfigurable weblabs based on the IEEE1451 Std. 1359
Reflections about Teaching Engineering Graphics: Knowledge and Competencies Management 1509
Research-based approach application for electrical engineering education of bachelor program students in Riga Technical University 695
Retaining and Retraining: An Innovative Approach to Educating Engineers in a Changing Economy 1551
Retaining electronic engineering students by project- and team-work from the first semester. 1327
Reviews and Findings on Implementing Active Learning in a Large Class Environment 1565
Role of Faculty in Promoting Lifelong Learning: Characterizing Classroom Environments 381
Role of regional consortia in OCWC: OCW-Universia
Scientific project management course introduction in doctoral studies in Riga Technical University 369
SecondLab: A Remote Laboratory under Second Life 351
Simulations in Undergraduate Electrodynamics 1091
SOA-based Architecture for a Generic and Flexible E-assessment System 493
Social Media Enhanced Studying and Learning in Higher Education 137
Some Research Questions and Results of UC3M in the E-Madrid Excellence Network 1101
SPIRIT - A Life-Cycle Based Gender Mainstreaming Concept at the University of Stuttgart 853
State-of-the-art simulation systems for information security education, training and awareness 1909
Student Internship Placements. Improving the quality of engineering internship programs. 91
Student Motivation and Cross-curricula Development through e-learning applied to cooperation 913
SUBA – An innovative pedagogical experience 173
Supporting Person-Centered Learning: Does the Choice of the Learning Management System Matter? 885
Supporting the Delivery of Learning Contents with Laboratory Activities in SAKAI 165
Teaching Digital and Analog Modulation to Undergradute Information Technology Students Using Matlab and Simulink 685
Teaching Microprocessors Design Using FPGAs 1189
Team Teaching for Web Enhanced Control Systems Education of Undergraduate Students 1527
Technical congress proceedings as a reusable digital objects educational source 423

Technological Development, Sustainability: Discussions about International Aspects of Engineering Education 1057
Telefónica University Chairs Network 1752
The developing of personal and professional skills in automotive engineers through university competitions 1493
The development of professional mentoring for engineers undertaking a workbased learning Masters degree 389
The influence of design problem complexity on the attainment of design skills and student perceptions 287
The LULA Project by the Telefónica Chair of the University of Extremadura - LULA Linux Distribution for Latin American Universities 1765
The Montegancedo Astronomical Observatory. The first free remote observatory for learning astronomy 1367
The New Degree in Materials Engineering at the Technical University of Madrid (UPM) 807
The Role of Superior Education Institutions on Post-Secondary (Non Superior) Education 1277
The use of agents to represent learners in role-play training 185
The Use of Role Playing in Engineering Curricula: a Case Study in Human-Automation Systems 1335
Three Online Neutron Beam Experiments Based on the iLab Shared Architecture 145
TICTAC: Information and Communication Technologies for Augmentative Communication Boards 1785
Tokyo Tech Graduate Program Allied with Thailand: TAIST (Thailand Advance Institute of Science and Technology) - Tokyo Tech 1031
Tools for Collaborative Development of Visual Models and Languages 1597
Towards the loose coupling between LMS and Remote Laboratories in Online Engineering Education 1937
Toy Design Experience: Improving Student's Motivation and Results in a Final Year Subject 1483
Training Microsystems Technologies in an European eLearning Environment 113

Trends of Use of Technology in Engineering Education 787
Use of Advanced Technologies in a RF and Microwave Engineering Course 811
Use of E-Learning functionalities: results of a survey along Spain 1441
VenDASys – a versatile experimentation platform 205
Virtual analog and digital communications laboratory: LAVICAD 429
Virtual flute: electronic device that uses virtual reality to teach how to play a flute 211
Virtual University as a Role Playing Game 743
VirtuaLab, a Teaching/Learning System for 8 and 32 bits Microcontrollers 1419
Web 2.0 contents for connecting learners in online Learning Network 1211
WEB Instruments 585

Web-based Time Schedule System for Multiple LMSs on the SSO/Portal Environment 153
Who enrolls in electrical engineering? A quantitative analysis of U.S.A. student trajectories 839
WikiDIS: a case of collaborative content management system for educative community 601
Wireless4x4: an integrating learning experience for Telecommunications students 1265
Workshop on VISIR electrical and electronic remote lab: Practical view 1797
Workshop on VISIR electrical and electronic remote lab: Principles and educational view 1663
yPBL methodology: a problem-based learning method applied to Software Engineering 1819