Experience of the design of a MOOC in Engineering for the learning of microcontrollers

Eduardo Romero Bruzón
Associate Professor
Faculty of Engineering, University of Cadiz
Puerto Real (Cádiz), 11519 Spain
E-mail: eduardo.romero@uca.es

Carlos Rioja del Río
Associate Professor
Faculty of Engineering, University of Cadiz
Puerto Real (Cádiz), 11519 Spain
E-mail: carlos.rioja@uca.es

Arturo Morgado Estevez
Associate Professor
Faculty of Engineering, University of Cadiz
Puerto Real (Cádiz), 11519 Spain
E-mail: arturo.morgado@uca.es

Keywords: MOOC, Microcontrollers, LLL,

INTRODUCTION

Why a MOOC about microcontrollers? In 2011, around 75 million vehicles were manufactured, of which 20 million were produced in Europe alone. On average, each vehicle contains chips worth about USD 300. One of the first steps of this work was the review of the list offer from the main MOOC platforms around the world (like Coursera, Udacity, Edx, Open2study, MiriadaX, FutureLearn, etc) and it seems to be there aren´t many MOOCs of engineering issues and between them, with less perform laboratory practice, due to the difficulty of conducting a traditional classroom practices. The cost of equipment and the difficulty of assessing skills, which are usually very applied, hinder the existence of MOOCs on Engineering. Among the many issues there is one within the control area: They are microcontrollers. A large number of devices that surround us in everyday have incorporated a microcontroller, used as a control element, which allows taking decisions on actions to be performed and gives information about the processes it controls. This massive presence of microcontrollers makes it a commodity demanded by many technicians. Worth the effort to design a MOOC on microcontrollers.

1 MOOC AND MICROCONTROLLERS

To make this work, firstly we have searched references MOOCs about microcontrollers. We have visited different platforms to check if there are these kinds of courses. In almost of all of them are separated into categories, and virtually no related engineering and computer science, compared to all others. In edX [1] platform with 467 courses, more engineering-related categories are Computer Science with 88, Electronics with 24 and Engineering with 91, although courses typically are assigned to more than one category and therefore they aren´t absolute values of the number of courses.

In Electronics there is one entitled Embedded Systems-Shape The World [2] from the Technological University of Austin, of January 21, 2015, during 15 weeks and 10h per week. In this course you work with microcontrollers ARM Cortex M4 family and a development board Texas Instruments. The student must acquire the equipment necessary for the practice.

In MiríadaX [3] with 51 courses in the category of Technological Sciences, there is one titled Robots and video games in the classroom: Scratch and Arduino 3rd edition of the Pompeu Fabra University April 21, 2015.It's during 6 weeks.

In Coursera [4] in the Engineering category there are 84 courses. One of them is titled Understanding microcontrollers in which you work with Arduino, from the École Polytechnique Fédérale de Lausanne. It's during 7-week and 7 hours per week.

In Udacity as well as other platforms with fewer partners there is anything about microcontrollers at the moment of this paper.

2 JUSTIFICATION

This article derives from the interest of a group of professors from the University of Cadiz in design and implement an Engineering MOOC and specifically about microcontrollers. Moreover as noted above there are few MOOC them in the world.

Today the development of embedded systems is massive. Any device that provides digital information or decisions required is based on a microcontroller. Its scope is everywhere, in the healthcare, transportation sector, toys, household products, communications, home automation, etc.

This widespread use of microcontrollers and the challenge of designing a MOOC has motivated us to work on the issue.

3 PLATAFORM

There are great platforms which bring together a large number of institutions, mostly universities and other platforms with less scope supported by an individual university and a small group of partners.

We preferred to choose a powerful platform and since our university is a member of MiriadaX, we have chosen to use it. This choice does not mean that in the future we can offer courses on other platforms. Also in MiriadaX have not found any course on the microcontroller with which we will work.

4 CONTENT OF THE MOOC

This course deals with the ARMv7-M core from ARM Cortex M4 microcontroller. To learn to program this micro we used the Integrated Development Environment µVision v5.12 from the company Keil [5].

The world of embedded systems and microcontrollers is extensive and has many lines of work. This leads us to think about making at least two levels.

The purpose of this MOOC is a basic level course programming in assembler and C on a NXP microcontroller, the LPC4088. It will design a course to be completed in 8 weeks. It is structured into 8 modules one per week. Subtitled audiovisual material, theoretical support material and an evaluation system for each module that enables the level of knowledge of the participants and a final overall assessment will be offered. In a module 0 a brief description of the subject will be held. An initial test is mandatory for detecting the level of knowledge at the beginning of the course, despite we have very clear requirements for the users.

At the end of the course students should know the characteristics of the microcontroller (eg use registers, memory maps, conditional statements ...) should also be able to develop programs in assembly language to give commands to the microcontroller. Examples of use may be building algorithms, data conversion, using input / output ....

Mainly the profile of the students of the course is people interested in technology and in the knowledge of how things work. Structured thought and orderly behavior are good characteristics of users. It is always positive to have prior knowledge of programming, but not absolutely necessary because the basics will be provided within the course.

5 COLLABORATION OF STUDENTS IN THE DESIGN OF MOOC

Before to the start of the design, a survey was passed to 30 students from the Industrial Computing module (a subject in which they are working with microcontrollers). This module is taught in Electronic Engineering Degree, third year, School of Engineering from University of Cádiz. The purpose of the survey is to determine the potential interest of this type of courses.

Table 1. Survey

Nº		Question		
1		Are you interested in a MOOC about microcontrollers?	YES	NO
2		Divide the following items in 8 modules	Module	
	1	Introduction to Microcontrollers		
	2	General knowledge of the core ARMv7-M		
	3	Memory organization, records and data types		
	4	Load and store instructions		
	5	Basic arithmetic instructions		
	6	Jump instructions		
	7	Multiplication and division instructions		
	8	Other arithmetic instructions		
	9	Using Microvision		
	10	Organization assembler programs		
	11	Conditional execution of instructions		
	12	Programming techniques		
	13	Troubleshooting for programming		
	14	Microvision Assembler		
	15	Transfer Instruction XPSR		
	16	Instruction load and store multiple		
	17	draw		
	18	masks		
	19	Control Structures		
	20	Assembler and C		
	21	Data Types in C for LPC4088		
3		Do you think that learning assembly language useful?	YES	NO
4		Would it begin learning µC directly in C language?	YES	NO
5		Do I best would include the operation of µC if you start programming the peripherals?	YES	NO
6		What two paragraphs in question 2 considered more difficult to understand?		
7		What two paragraphs in question 2 considered easier to understand?		
8		What would add another section to point 2 ?		

The result of the survey was as follows:

- In question 1, the answers about the interest of MOOC are equally for and against.

- In Question 3, a majority considered that learning of assembler language is helpful.

- In Question 4, just over half are in favor to start programming in C language directly.

- With respect to program peripherals of the µC from the beginning, the answers are not clearly opting for it.

About the sections considered more difficult to understand, most have highlighted those related to the multiple transfer with memory and programming techniques.

As for the easiest are simple memory transfers and basic arithmetic instructions.

Concerning point 2, a debate about the course content was performed and discussed where we had to go deeper into the explanations and examples to make in µVision and its simulation. One of the conclusions was the necessity of a longer time with the MicroVision© platform. The result was as follows:

Module 1. Items 1, 2 y 3

Module 2. Items 4, 5, 6 y 11

Module 3. Items 9,10 y 14

Module 4. Items 7 y 8

Module 5. Items 12 y 13

Module 6. Items 17, 18 y 19

Module 7. Items 15 y 16

Module 8. Items 19 y 20

6 COMPETENCES AND ITS EVALUATION

After this course the student acquires the following powers:

- Meet microcontrollers
- Meet the assembly language
- Program assembler for LPC4088
- Know the basic instructions ARMv7-M core
- Manages the Keil's µVision.
- Relates assembly language and C.
- Program in C for the LPC4088.
- Is able to recognize control structures in programs.

But how to evaluate knowledge gained? In addition to conducting tests on various issues, such teaching is fundamental practice exercises and work. To evaluate these activities, we resort to the results should give the solution in each µVision simulation. Use of peer review will be done and how overall assessment conducting a thorough job in C and/or assembly, that will result in certain outcomes and which has prompted several occasions.

7 PROBLEMS OF THE DEVELOPMENT OF REAL WORK.

In learning any material engineering and including working with microcontrollers, it is essential to perform laboratory practices. For a course like MOOC is a complicated subject performing practices remotely with hardware and components for the development of embedded systems such as those found in a laboratory Industrial Informatics. There are some experiences like the University of Deusto, which has created a virtual laboratory WebLab Deusto [6] which can perform labs distance on

very specific and fixed equipment, ie with little flexibility to allow change in practice through the device. To this must be added the difficulty of finding a method of evaluation of practice and / or final work to determine the acquisition of relevant skills.

There is a distance learning course on microcontrollers that solves this situation indicating students the need for the purchase of equipment to perform the practices. When this material is cost would be permissible and perhaps assumed by the student. But such a course would not be a true MOOC.

In our case we only use the µVision IDE in its demo version, which is free to use and available on the website of Keil. For the next level of the course on microcontrollers, will try to do internships at a distance. Is available to the student, a job with software and hardware so you can perform all the necessary practical skills and acquire the corresponding course.

It is working on a hardware configuration that will enable the realization of laboratory remotely with the ability to modify elements of the system and with the same team to do different practices. This laboratory is integrated into a MOOC and acquiring closer to the traditional classroom knowledge will be achieved.

8 CONCLUSSIONS

Once a study has been realized, and there has been detected the need to create and improve the presence of concepts of engineering inside the increasing world of the MOOC, we show here some bases for the development of massive courses in Engineering.

We focus on microcontrollers (which tradionally is a tought topic), and we find particullary interesting the use university students opinion, which are very valuable for courses not necessarily prepared for university students.

REFERENCES

[1] https://www.edx.org/courses. (2015).

[2] Valvano, J., Yerraballi, R., (2015) Embedded Systems-Shape The World, MOOC, UTAustinX.

[3] https://www.miriadax.net/web/general-navigation/cursos. (2015)

[4] https://www.coursera.org/courses. (2015)

[5] https://www.keil.com/download/product/. (2015)

[6] http://www.weblab.deusto.es/. (2015)