Integrating MOOCs in Embedded Systems Blended Courses

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Abstract

Massive Open Online Course (MOOC) paradigm has been growing in less than a decade from a life-long learning approach to a state-of-the-art method of offering a large plethora of courses and even specializations. Not only higher education, but also private companies started to manifest a growing interest into all the possibilities this technology is offering. This phenomenon received extra-consideration when renowned universities like Stanford, Harvard, École Polytechnique Fédérale de Lausanne, the Massachusetts Institute of Technology and Rice University started offering such courses. Embedded Systems field, on the other side, is one domain that continuously needs attention from educators. The concepts should be presented in a very friendly and approachable way, while in the same time preserving a practical, applicative vision. This paper presents a modality of integrating MOOCs into embedded systems higher education. The obtained results show that students prefer such a mix to the classical classroom methods of teaching.

Keywords: Massive Open Online Courses (MOOCs), embedded systems, blended courses, higher education

1. Introduction

Coined in 2008, the term Massive Open Online Courses (MOOCs) has become one of the common words used now-a-days among students, engineers and researchers. The year 2012 was called "the year of MOOC" (Wu, 2016) and it is the moment when different private companies joined their efforts with top universities to offer high-quality MOOCs (Baran & Baraniuk, 2016). The impact of MOOCs is felt even in the industry because different companies are developing special programs by which are paying their employees the tuition of following their desired courses on MOOC platforms. Such a facility is deductible based on the obtained certification. Different courses have been offered, which are currently migrating towards specializations due to economic reasons (Baran & Baraniuk, 2016). MOOC paradigm offers a number of tangible advantages: providing high quality education, increasing accessibility of higher-education studies, independent learning and so on.

Even if MOOCs have been initially designed as standalone courses, one of their state-of-the-art use cases is that of blended courses. Such courses have been first introduced more than ten years back (Holotescu & Grosseck, 2014), but the usage of the new education paradigm which are MOOCs, is pushing forward the promotion of such an approach. Blended courses basically deal with a combination of classical teaching methods and also online activities and in the same time offer an integration of synchronous and asynchronous learning tools.

One of the academic fields where a spectrum of methods is being researched that can enhance student's understanding is that of embedded systems. A number of approaches have been proposed (Bogdan, 2016), (Bogdan & Ancusa, 2011), (Bogdan & Ancusa, 2012), but the problem remains: students find the concepts as being very tedious and tend to avoid building practical solutions. This paper is presenting the case of introducing MOOCs with no synchronization into the Embedded Systems courses at "Politehnica" University of Timisoara, in Romania.

The rest of this paper is organized as follows: the second section presents previous work relevant to the topic of this paper, while section three offers the used methodology. The last section is devoted to obtained results and conclusions.

2. Previous Work

This section is presenting, first of all, previous work related to MOOCs. Secondly, different approaches to teaching embedded systems are discussed and also how embedded systems have been taught by using MOOCs. In the end, state-of-the-art literature review regarding teaching blended courses by incorporating MOOCs is offered.

The Massive Open Online Courses have been defined in (Azvedo & Marques, 2016) as being "sets of learning activities and resources, web-based, free-of-charge and usually with no prerequisites, which can be explored simultaneously by hundreds of people." There are available two types of MOOCs, namely cMOOCs and xMOOCs (Grosseck & Holotescu, 2015). In the first category the participants are required to contribute to the content of the course by bringing new additional, relevant information specific to content of that course. The xMOOCs appeared after the cMOOCs when different universities like Stanford, EPFL, the Massachusetts Institute of Technology, Rice University (Wu, 2016), (Baran & Baraniuk, 2016), (Azvedo & Marques, 2016) started to offer structured and instructor-based MOOCs. Such xMOOCs are generally including different videos, subtitles (can vary to different languages), recommended readings, assignments and some form of assessments.

Different approaches are presented in the literature regarding building abilities to categories of computer science students (Babori & Fassi, 2016), (Chirila & Ciocarlie, 2015) and especially to those students whose aim is to practically learn embedded systems (Bogdan & Ancusa, 2012). Relevant papers are (Bogdan, 2016) and (Bogdan & Ancusa, 2011), where the authors present a method to teach embedded systems by means of industrial processes. This means that the students not only have to acquire practical knowledge about designing an embedded system application, but also have to to cope with a specific development process.

The problem of moving different embedded systems courses towards MOOCs has been treated in the literature and we might say that this is done fairly with the appearance of the July 2016 number of IEEE Signal Processing Magazine. This is devoted for largely presenting the case of Digital Signal Processing courses which have been offered by École Polytechnique Fédérale de Lausanne, the Massachusetts Institute of Technology and Rice University on edX and Coursera platforms (Wu, 2016), (Baran & Baraniuk, 2016). Some other relevant papers are (Malchow & Renz, 2016) and (Malchow & Bauer, 2016) which present a method of teaching Java programming language by using embedded systems devices such as LEDs and sensors.

In (Bruff & Fisher, 2013) and (Bruff, 2012) is presented the case of a blended course (Machine Learning course at Vanderbilt University) which uses a Coursera platform to adopt different resources that can be used in the on-class course. A step by step checklist for using a MOOC course to create a blended course is presented in (Holotescu & Grosseck, 2014) and (Grosseck & Holotescu, 2015). More than that, in (Holotescu & Grosseck, 2014) we find a systematic research for blending MOOCs in a course, but taking into consideration the synchronicity between the course and MOOC. It is defined the fact that there is no synchronization between the MOOC and the blended course when students have to study different resources from the MOOC, but the assignments and evaluations are conducted in the blended course. There is a synchronization between the two approaches when students not only study all the resources, but also take part in the assignments and different forms of evaluation. A detailed overview of MOOCs and OER used in Romania, including two examples of blended courses are offered in (Vasiu & Andone, 2014), but also in (Bogdan, 2017).

3. Methodology

This paper presents an approach of integrating different MOOCs into a traditional embedded systems course. Different topics and MOOC platforms were integrated with the Spring 2016 undergraduate Embedded Systems courses which are taught by the author at the third year of study; the involved students are both on-site and distance learning. For the distance learning students, the platform which is used is called the Virtual Campus of "Politehnica" University of Timisoara

(https://cv.upt.ro/course/view.php?id=1563). All the topics, discussions, messages were posted on this platform (Figure 1). For the on-site students, the activity consists of face to face meetings, presentations and discussions. These two courses were presented in Romanian language, but all the students can meet up the requirements of following an English technical course due to their previous English seminars and courses.

The topics of the Embedded System course combine technical explanations with practical exercises, so that in the end the students would have a foundation of this domain, but also practical abilities to attack a specific design problem:

Figure 1. Embedded Systems course space for distance learning

- Introductory course: reviews specific notions and terms from previous courses which are very useful in this present course;
- What are embedded systems: presents definitions, but also practical examples and applications of embedded systems;
- Microcontrollers course: general diagram, peripheral devices;
- Programming a microcontroller: C programming of a microcontroller;
- Developing practical applications;
- Testing embedded systems: principles of testing embedded systems based on ISTQB (International Software Testing Qualifications Board) certification.

The goal of integrating embedded systems MOOCs into this course comprises a two-fold approach:

- Enlarge students' understanding about embedded systems which, in itself, is not a straight forward field of study;
  - Different notions are explained from different point of view, so the students have more learning opportunities;
  - Obtain auxiliary support regarding different specific topics;
  - Getting to know a large spectrum of applications and design approaches;
- Allow students to become aware with the MOOC paradigm
  - Learn about the most important platforms, courses and specializations which are offered on such technology;
  - Critically evaluate their usage for their own professional development;
  - Making them aware about the "continuous learning" approach.

Research methods

During the first meeting of the blended course, a presentation on Massive Open Online Courses (MOOC) was offered to the students. They were able to ask questions and have a clear understanding of this. Those students who wanted to further read on this topic, additional resources

were provided at the end of the presentation. Students' task was to enroll into such a course and complete at least 30% of the MOOC activities, counting to 20% of their final mark of the blended course. The following steps were followed in order to complete MOOC's integration into the Embedded Systems course:

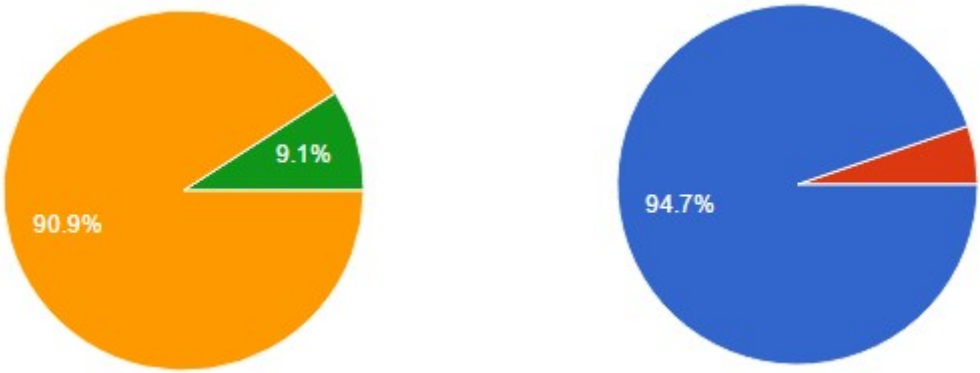
1. MOOC's proper selection
    a. As previously presented, at the first face to face meeting, students were introduced to MOOCs. For the distance learning students, they had a special activity called MOOCs in Embedded Systems, where the same presentation was offered. During this presentation different MOOC platforms were introduced, such as Coursera, Udemy, Udacity, Khan Academy and Future Learn, but also the concept of MOOC directory, such as MOOC List (https://www.mooc-list.com/?static=true).
    b. During this presentation, the author presented also the concept of specialization which very prominent on some platforms as Coursera.
    c. Students were invited to choose a course specific to embedded systems topic, so they were encouraged to search after embedded systems, microcontrollers, internet of things courses, but this was not a limitation. As an example, the author demonstrated how one can enroll to a course on the *Internet of Things and Embedded Systems Specialization* from Coursera.
    d. As a mandatory activity, students were asked to send the name of a course which they prefer to enroll to. A number of 3 students sent a totally incorrect course, so further explanations were supposed to be offered.
    e. Another activity was the completion of a MOOC activity - related questionnaire.
    f. For those students who completed more than 60% of the MOOC, the theoretical part of the blended course was automatically recognized as passed.
2. Actively participating in the MOOC
    a. All the students had to actively participate in the MOOC activities. One of the main concerns of the students even after the initial presentation was if they were supposed to pay, so further clarifications were offered: it was a free subscription, so no student had to pay for the course, only those who wanted to have a certification.
    b. Students had the chance to ask questions on the forum, to solve the homework and participate in different activities. For those students who enrolled in a course that did not offer the possibility to submit homework if they had not paid the full price, the homework could not be evaluated during the MOOC.
3. Create a learning portfolio
    a. Students had to construct a learning portfolio which was supposed to contain at least: those questions that they asked on forums and the consequent answers, quizzes, homework, other assessments that they participated into, proof of their progress.
4. Submit the portfolio for evaluation
    a. As a mandatory activity, each student had to create an archive with all the portfolio's material and send it to the author (in the case of on-site students) or upload it on the Virtual Campus platform (in the case of distance-learning students).

4. Obtained results

One of the ending tasks of the MOOC activity was that the students had to complete a survey. From the two specializations (on-site and distance-learning), a total number of 72 students were enrolled into this activity; 57 students (79.16%) chose to complete the survey. The survey revealed the fact that only 16% of the students have already been enrolled in a MOOC. During this activity 70% of the participants preferred to use Coursera as a platform, while the rest of 30% used Udemy (20%) and edX (10%). It is interesting to note that 64% of the students have completed the

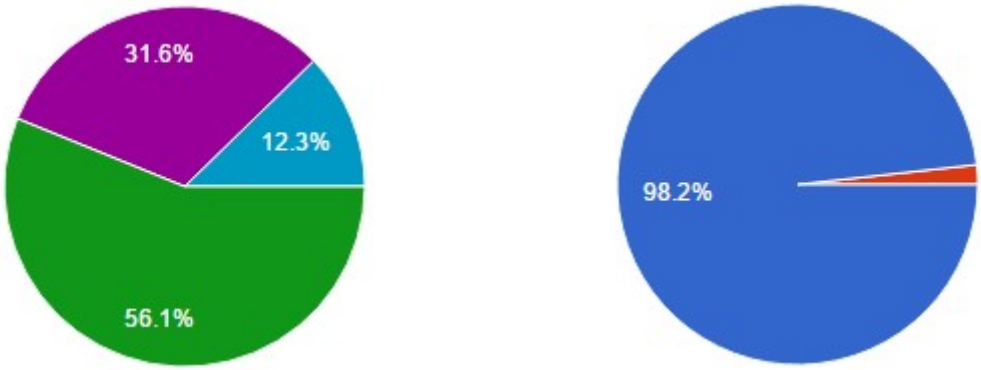
entire course, even if the requirement was only 30% and it was surprising to see that 9% of the participants even wanted to pursue a certification (Figure 2a).

One of the key points of this study was to understand how students perceive integrating MOOCs into Embedded Systems courses. In this regard, we can see that 94.7% of the participants appreciated that such an experience helped them to better understand this domain (Figure 2b). In addition to that, in Figure 4 it is highly recommended to notice that students were asked to evaluate how advantageous is to follow an Embedded Systems MOOC from the point of view of theoretical and practical knowledge. 49% of the students rated this experiment as most advantageous, 29.8% as advantageous.



(a) (b)

Figure 2. Distribution of students who obtained a certification (a); Integrating the MOOC activity helped students to better understand Embedded Systems course (b)



(a) (b)

Figure 3. Distribution of students' opinion regarding the way an Embedded System course should be taught in relation to MOOCs (a); Distribution of students who would follow again a MOOC (b)

Another key element of this study was to understand if students prefer just following MOOCs instead of traditional embedded systems courses. The results of this point are presented in Figure 3a which shows that 56.1% of the students prefer a mix between MOOCs and the classical approach of teaching embedded systems, in other words this variant of integrating MOOCs into courses is most preferred by students, while 31.6% of the students prefer the MOOC variant to traditional courses. In Figure 3b it is presented the fact that the great majority of the students (there is only one exception) would take again a MOOC.

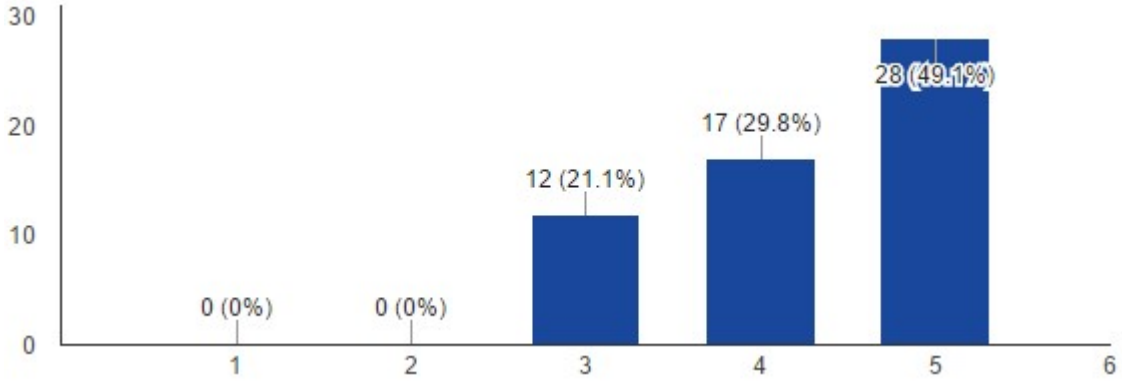


Figure 4. From the point of view of the acquired embedded systems knowledge (theoretical and practical), how would you rate the experience of following an Embedded Systems MOOC? (1 = extremely disadvantageous, 5 = most advantageous)

Lessons learned

After completing the experiment of integrating MOOCs into an embedded systems course, different lesson can be learned. These will be presented following:

- Students' choice of a specific course can be very tedious. In our experience, students cannot decide upon a certain course, therefore some course examples are indeed very helpful.
- Sometimes students tend to choose from courses which are not specific for that particular domain of the blended course. In order to avoid explaining again what was previously said, it is advisable to have a clear explanation in the first presentation.
- The fact that a paid course is not a mandatory option in order to complete the activity should be loud and clear mentioned in the initial presentation. In this way, many forum questions can be avoided.
- It is a good idea to have a format for the portfolio, also an example because students do not necessary understand how they should report the progress percentage.
- Clear deadlines for choosing a MOOC and for uploading the portfolio should be established.

5. Conclusion and future work

Massive Open Online Courses (MOOC) have proved to be a virtual space to self-paced and active learning which offer the participants the chance to take part into global learning communities. The MOOCs are a medium to build constant education and learning autonomy. Embedded systems are nowadays the motor which build smart cities and future societies. This paper presents a method to integrate MOOCs into embedded systems courses. The obtained results show that students are extremely favorable to such an approach, but also to MOOCs as a paradigm.

As future work our plan is to continue extending this method to English-taught blended courses, in the same time trying to diversify the resources and practical exercises.

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