Evaluation of Cloud-based Open Educational Resources for Teaching Microelectronics

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***Abstract**: As participant of an Erasmus+ Project called MECA (Micro Electronics Cloud Alliance) our team together with Lightware Visual Engineering Company aims to build and host one active node of a Europe wide cloud platform to support the education in the field of microelectronics. In the framework of MECA, open educational resources and learning materials were developed by our team. The integration of the MECA platform and materials into the courses, pilot test regarding its application for self-study via remote access, and the evaluation of the feedback of the participating students is discussed in the paper. The positive feedback encourages us to offer our courses for inclusion into the catalogues of an on-line education center in Hungary and also of the world's leading Massive Open Online Course (MOOC) providers. This will help to disseminate the information about our courses and attract more students to take the courses on-line.*

1. INTRODUCTION

The rapid development of modern information technology forebodes and facilitates a forthcoming revolution in education. The need for modern, interactive and computerized learning materials or even courses which could be delivered via the internet is increasing, which is clearly visible in the increasing number of eLearning materials being developed worldwide, in nearly every possible topic, including microelectronics [1, 2]. Our consortium has developed a cloud-based platform, to support the education in this field. Cloud computing could make possible to easily share and distribute training materials and also provide a hardware & software platform which can be used in practical education in on-line courses. In our previous paper, the challenges and feasibility of putting together such a cloud platform were investigated [3]. In this current work we focus on the direct application of the system in courses related to microelectronics technology at our university.

In the last few years, the faculty members of many highly ranked universities around the globe planned and designed the content of thousands Massive Open Online Courses (MOOCs), which is then delivered online through learning platforms like Coursera [4], Udacity [5], and edX [6].

The acronym of MOOC emerges from the e-learning, distance education and open educational resources (OER) concepts, first termed in 2008 by Dave Cormier of the University of Prince Edward Island [7]. In many aspects the MOOCs exceed the predecessor concepts and thus they should not be regarded only as a collection of electronically distributed, traditional course materials. Many MOOCs provide interactive user forums to support community interactions among students and lecturers. These types of MOOCs, which focus on connections and community are also called cMOOCs, in contrast to xMOOCs, which have a much more traditional course structure, typically with a clearly specified syllabus of recorded lectures and self-test problems. Besides this difference in basic approach, MOOCs may differ in other aspects as well, e.g. whether they provide open access and license to the materials (cMOOC) or open access, but restricted license (xMOOC), or whether they provide individual learning on a single platform (xMOOC), or networked learning across multiple platforms and services (cMOOC). As it can be seen, the concept of MOOCs is not strictly defined, or as the illustration in Fig. 1 ingeniously remarks: “In MOOC every letter is negotiable” [7].

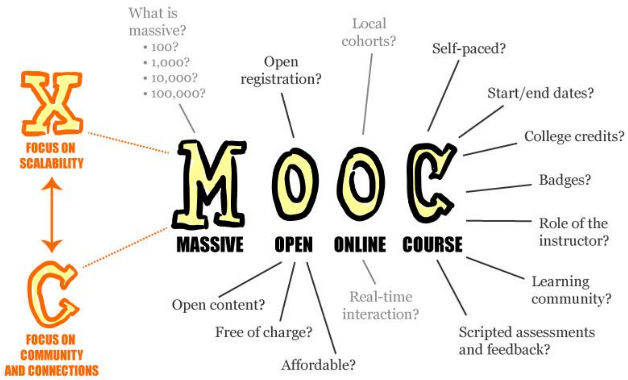

Fig. 1. Poster, entitled "MOOC, every letter is negotiable", exploring the meaning of the words "Massive Open Online Course", by Mathieu Plourde [8].

Generally, the MOOCs make it possible for the universities to extend a high-quality education to more people from all over the world, which is in line with the objectives of the MECA Erasmus+ project and with the mission of all the participating universities. This is why we are motivated to offer our courses to be included among the courses of the world’s leading MOOC providers.

In this paper we focus on the demonstration and evaluation of our open educational resources and related cloud platform, regarding various courses, developed by our department, together with Lightware Visual Engineering Company, and offered by our university. In Chapter 2 we briefly introduce the platform and the system architecture, while in Chapter 3 we present the results of a pilot test regarding the application of the platform in the framework of a university course.

2. OUR EDUCATIONAL PLATFORM

2.1. Technical content and organization

In the frame of the project, 23 MOOCs and OERs (Open Educational Resource) were developed, which covers all the advanced topics required for microelectronics engineers. The developed courses can be reached at the projects’ own Entry Point [9]. The educational courses can be categorized into three main fields including; a) the field of technologies applied in microelectronics; b) design and modelling considerations for both device level and product level; virtual laboratories regarding electronics manufacturing and multimedia enhancement of teaching sensors and MEMS (Microelectromechanical systems). Learning outcomes were defined based on EU recommendations; the acquirable knowledge, skills and competences were described for all courses.

Altogether four educational courses were developed by our department:

- Technology of Electronics Products
- Assembly and Inspection Technologies
- Virtual Laboratory Support for Microelectronics Packaging Education
- Multi-Media Enhancement of Teaching Sensors and MEMS

These courses cover the technologies and techniques used in mass manufacturing of electronic circuits as: fabrication of printed circuit boards; assembly of electronics components (mainly PCBA); wafer level technologies; thick-film and thin-film technologies; inspection and test methods of PCB-based assemblies.

In order to evaluate the developed open educational resources and massive open online courses, a survey has been conducted among our students. The survey included questions about quality and style of the courses; quality of illustrations within them and ratio between texts and illustrations. The students had to compare the developed learning courses to other familiar learning materials. The students had to provide information about their recommendations to other students, or colleagues working in the industry. The detailed results of the survey are presented in Chapter 3.

Besides the educational materials, several free software tools for engineers were investigated to offer them in the frame of the cloud-based teaching system. The technical specifications about the cloud-based teaching system are detailed in Chapter 2.2. The free software tools include CAD applications for electrical design (schematic) including spice simulator [10], for PCB design (layout) with 3D viewer [11] and for mechanical design [12]. Additional, related tools are offered within the m-cloud teaching system, which allows preparing high quality images for documentation, project reports, and for thesis works.

This contains free tool for editing bitmap-based images [13], and also for editing vector graphics [14].

2.2. System architecture

After the detailed evaluation and comparison of different approaches an IaaS (Infrastructure as a Service) model was selected for the realization of the software platform. The applied specific product is the Apache Cloudstack [15] which is a solid, open source framework.

A node of a basic installation was set up at every technical project partners' location. This consist of exactly one cluster in one pod within one zone and should include one host computer, one primary and secondary storage at least. Setup parameters had been defined carefully to ensure the compatibility of each installation site during the integration. Parameters for networking, user management, naming conventions, etc. were strictly defined in an organized manner for all partners' node.

Nodes are connected by the so called region method where every installation node is identified by a given region number. This makes possible the access of all resources of all nodes for every participating project partners and also for the users of the final mCloud system later.

A unique solution was developed for the synchronization of working data among the regions. As IaaS cloud solutions rely on virtual machines, templates were defined for virtual machines supporting the teaching of specific training courses created by different project partners. Users of the mCloud are able to create the necessary number of specific virtual machines for given online trainings by simple selecting the desired template. However templates should be synchronized which means continuous updating and downloading of virtual machine templates. A central storage repository was set up for this purpose which is managed by an automated solution downloading, updating and uploading the templates through the internet among the partners' installation sites.

Our experiments showed that the mCloud is a solid, high performance system suitable for teaching many students in online courses in the same time.

3. PILOT TEST RESULTS

In October, 2017 we conducted a pilot test regarding the application of the cloud platform for remote access self-study in one of the courses at our university. The name of the ongoing course was "Electronics Technology" for 50 MSc students in Mechatronics Engineering. The topic was MEMS technologies and MEMS based sensors, and for this the "Multi-Media Enhancement of Teaching Sensors and MEMS" online course of the MECA package was used. A part of the materials was directly presented in a lecture (along with the introduction to our developed platform and system), while a part was purposefully not presented, and the students were asked to study it individually, by using our platform. All parts were included in the mid-term test, which the students took two weeks after the lectures. Along with the test, the students filled out an evaluation form with 14 questions aiming to assess the satisfaction of the students with the materials. Figures 2-7 present the distribution of the scores they gave to the given questions.

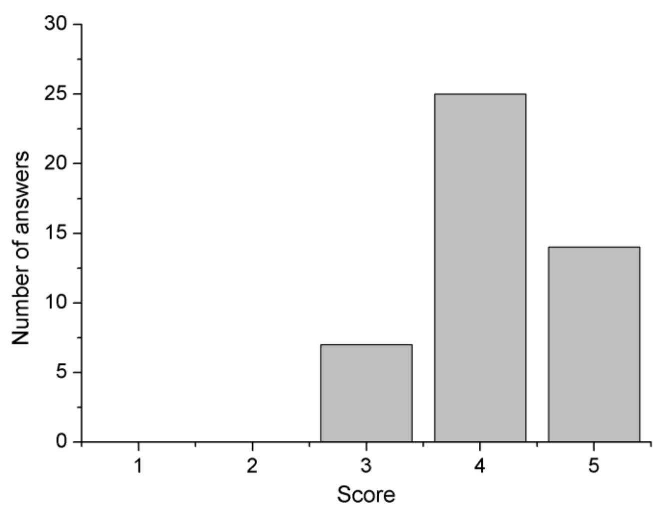

Fig. 2. Distribution of the answer scores for the question: "How would you rate the general quality of the course?", where 5 is the best possible score.

Based on Fig. 2, the general satisfaction of the students with the course was good (4), with more excellent (5) than moderate (3) answers. It is important to note, that based on their own admission, the students were involved with the course: only 18 % of them read less than 40 % of the available materials, while the majority processed 60-80 % of the course materials. (Note, that although 50 students participated in the test, not all of them answered every question in the questionnaire, thus sometimes the number of answers does not add up to 50).

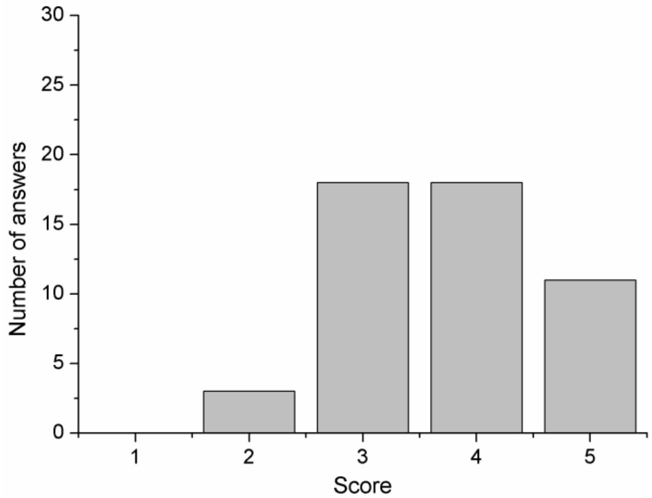

Fig. 3. Distribution of the answer scores for the question: ”How satisfied are you with the ratio of illustration and written text in the course material?”, where 5 is the best possible score.

An important conclusion of Fig. 3 is that the students were not entirely satisfied with the ratio of illustration and written text in the course material. Based on personal discussions, they told us, that they would like to see more written text, to be able to comprehend the topic in more detail.

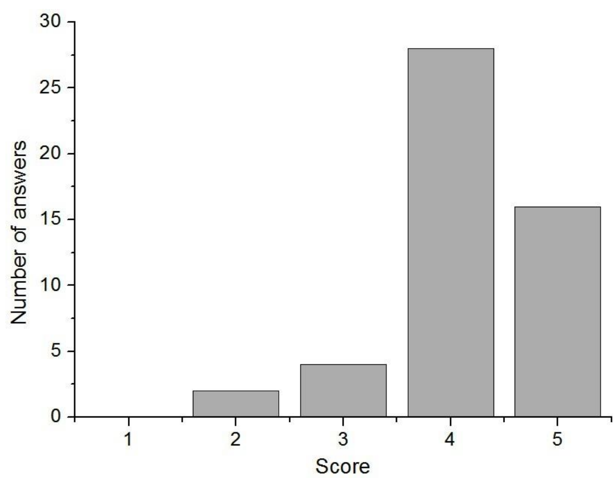

Fig. 4. Distribution of the answer scores for the question: ”How well does the course material complement the lectures, in your opinion?”, where 5 is the best possible score.

The distribution of answers in Fig. 4 and 5 give us some more insight in connection with this. In contrast to Fig. 3 more students think, that the course materials complement the oral lectures well (better scores than in Fig. 3), which means that together with the oral explanation of the lecturer they feel that the course materials can be effective for the comprehension of the topic.

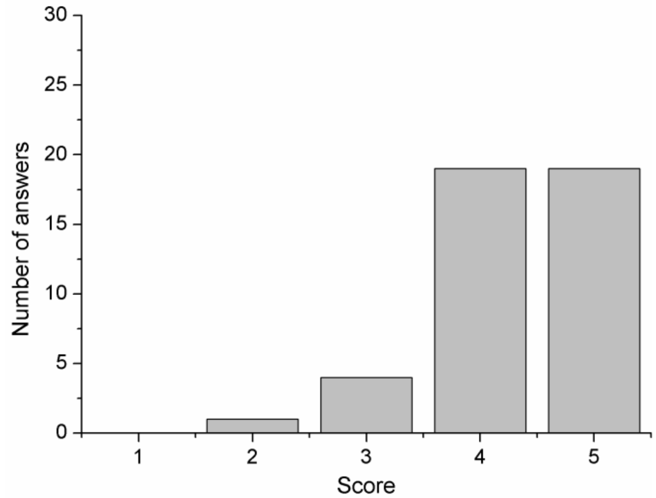

Fig. 5. Distribution of the answer scores for the question: ”Do you think that it would be a good idea to directly include the course materials in the university course, with related questions at the exams?”, where 5 is the best possible score.

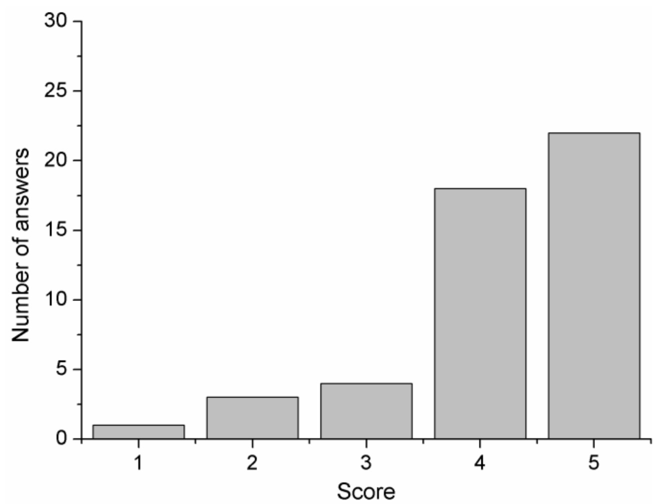

Fig. 6. Distribution of the answer scores for the question: ”Would you recommend the material for your fellow students at the university?”, where 5 is the best possible score.

We can conclude that, 1) the students require more explanation to the course materials than the current amount and 2) since the course materials were included in the mid-term test the students felt more comfortable about the parts, which were included in the oral lecture, compared to the part which they had to study individually.

Otherwise, the score distribution in Fig. 5 is a rather positive feedback: the majority of the students feel, it would be a good idea to directly include the materials in the university course (even with related questions at mid-term tests, exams), which indicates that they are more satisfied with the quality of our materials, than their currently used learning materials.

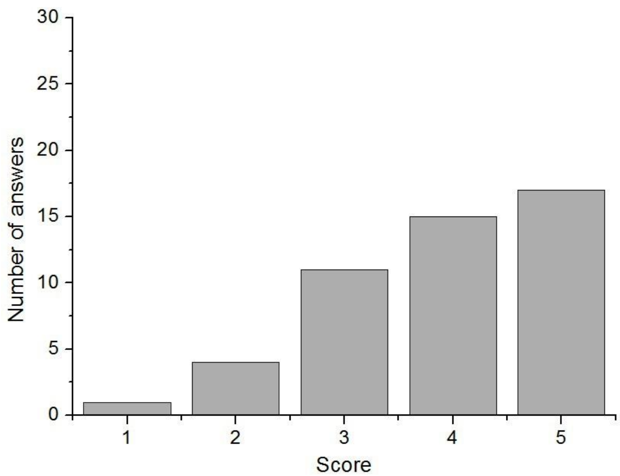

Fig. 7. Distribution of the answer scores for the question: "Would you recommend the material for your colleagues in the industry?", where 5 is the best possible score.

Also, the scores in Fig. 6 and 7 can be considered rather positive. The majority of the students would recommend the course to fellow students. The same is true with the recommendation to colleagues at the industry, however, in a moderate level. It seems, that the students think, the general quality or content of the course material is more suitable for other students than industrial members. This judgment may be affected by their perception of higher industrial standards.

4. Conclusions

Our department, together with Lightware Visual Engineering Company, developed and now host one active node of a Europe wide cloud platform to support the education in the field of microelectronics. In the framework of this project MECA, we developed four educational courses in different topics. The pilot test conducted at our university in an ongoing course showed, that the students are generally satisfied with the quality and content of the course material, and they would prefer to include them in their training. The amount of written text (explanation) should be increased in the course materials, since the students were more satisfied if they were used as part of the lecture. Based on the feedback of the pilot test we feel encouraged to offer our courses to be included among the courses of the world's leading MOOC providers.

Acknowledgements

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