Application of remote experiments in a secondary school using MOOC approach

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Abstract—**This paper presents first attempt to incorporate remote and virtual experiments in MOOC environment for the secondary school instruction. In case study the VISIR+ remote experiment of the WebLab-Deusto was used. The basic topic of physics "Resistors in series" was suggested for the mentioned above experiment. The open edX platform was employed to build the MOOC for the school lesson - we named it 'micro-MOOC'. The results could be helpful for secondary school sector representatives, education instructors, parents and policy makers to respond to current and future education needs.** (*Abstract*)

Keywords—*remote experiment; remote and virtual labs; micro-MOOC; secondary school; inquiry-based learning; 5E model (key words)*

I. INTRODUCTION

According to B. Gates the people with three skills - sciences, math, and economics will be successful in the future job market. The contemporary labor market demands from graduates and students different sets of competences such as professional, general, transversal… to progress in the 21st century. This influences tremendously on the transformation of European education system. Innovation and Impact are two words that teachers and instructors of education and training institutions hear and use in their day-by-day practice. Teachers are eager on innovative instruments to use them in class to make the lessons more meaningful, attractive, and interesting for students.

In 2015 the Open University together with Center for Technology in Learning at SRI International issued report [1] to explore new forms of teaching, learning and assessment for an interactive world, to guide teachers and policy makers in productive innovation. It was suggested that ten pedagogies will influence on the modern school education. One of them is "learning by doing science" with remote labs. It encourages exploring with authentic scientific tools and practices such as manipulating remote experiments or telescopes. This action can build student's science inquiry skills. Although a use of remote experiment in a school curriculum is not new teaching methodology it is still not extensively used in the school education system, partly, because their conservative culture that is never ready to support creative and inventive practices, partly, since teacher formal education has not prepared them to implement the novel instructional approaches [2]. The education instruction is called up to offer different methodology of implementation remote experimentation for school science practices. One of known action is the project Go-Lab, supported by European Commission. The science experiment is incorporated in inquiry learning spaces organizing inquiry tasks in 5 major phases: Orientation, Conceptualization, Investigation, Conclusion and Discussion [3, 4].

In this paper authors introduce a new methodology of an implementation of remote experiment using Massive Open Online Courses (MOOC) approach [5]. The open edX platform was used to offer the MOOC environment for school teachers. Because of a time-restriction nature of a lesson in a school, we suggest to use term "micro-MOOC" that means that just one small part of a topic is covered. Then Section II will be devoted to a short description of a MOOC approach in a classroom. Section III will introduce main feature of edX. In Section IV main characteristics of micro-MOOC, and VISIR+ implemented in it will be presented. As a conclusion, the training for teachers for integration this approach in their daily practice is planning as well as collecting the feedback on their satisfaction with this tool. The exercise presented in this paper was performed in frame of the supported by European Commission EARSMUS+ project "Open discovery of STEM laboratories (ODL)"

II. MOOC APPROACH

Almost past five years delivering university's education at massive scale has been a flagship of an innovation. Although till now, the critical debates on the pedagogical effectiveness of a MOOC movement do not stop. The high dropout rate of students who are registered at a MOOC is a major cause of concern regarding the long-term success, impact, and sustainability. At the same time, MOOC provides the instruction methods of learning that is useful with scale. The pedagogy of MOOC is based on learning through conversation and social networking. The students learn trough the exchanging ideas and sharing perspectives. One example, in July 2015, it was registered the British Council's course on preparing for the IELTS language examination that attracted around 270,000 participants. The question about the taking

exams attracted 56,000, what is almost 21%, comments and responses. It means that techniques from social networks, such as 'liking' comments, 'following' learners and educators, and rewarding popular learners and their contributions may be employed in education context successfully [6]. Other techniques such as badges to accredit learning, or crowd learning when students post questions, stories, images, videos and computer programs for other learners to answer or review, can improve involvement students in massive scale of teaching and learning. Therefore, MOOC technique shell be applied to complement the general knowledge (physics, math, biology) with social and transversal skills (such as team work, debating, formulating task, organizing answers and results in understandable for other students way, etc.) of school students.

Adaptivity and/or personalization is the main benefit of the MOOCs. It supports teachers and learners based on their preferences for pedagogical approach. The adaptive learning allows to harmonize the teaching process by organizing content for students in different context, from different perspectives, and in different ways. The neatly performing assessment as well as continuous intelligent feedback that motivate and provide guidance can maximize learning performance.

Nish Sonwalkar suggested the 4D ''learning cube'' pedagogical model (Figure 1). The model provides a multidimensional framework to organize learning objects developed in text, graphics, audio, video, animations, and simulations (y-axis) in the five learning pathways conforming to the pedagogy learning models (x-axis). The scientists suggest five Learning Models: apprentice (teacher–student interaction), incidental (using case study), inductive (using example), deductive (application usage), and discovery (learning through experimentation) [7, 8].

The z-axis of the cube indicates student- teacher increased interactivity, and, finally, the fourth axis is for social learning component such as blogs, wiki, podcasting, and YouTube to name a few.
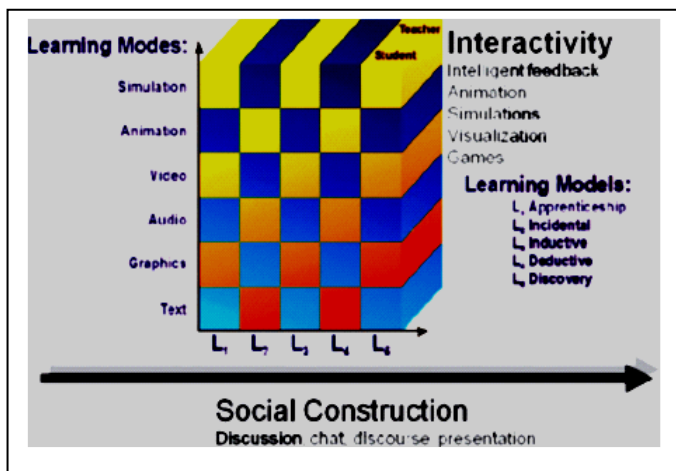

Fig. 1. The four-dimensional learning (4DL) framework for adaptive MOOCs [8]

Therefore, MOOC allows to synergy different learning strategies, modes, models, interactivities under umbrella of the social construction.

III. EDX AS A PLATFORM FOR MICRO-MOOCS DELIVERING

The edX was founded by Harvard University and MIT in 2012. The main task of this infrastructure was to be the MOOC provider that offers high-quality online courses from the world's best universities and institutions to learners around world. By 2016 the members of edX includes more than 90 global partners from top the QS World University Rankings®, nonprofits, and institutions.

In parallel with the pool of online courses, edX suggested Open edX [9]. It is the open-source platform (free of charge) that powers online courses with MOOC methodology. Institution can host their own instances of Open edX and offer their own learning resources to their students. Using the facilities of the Open edX platform educator can build the teaching and learning materials using available instruments as well as creating new features that meet their needs and expand the innovative learning solutions.

Open edX includes tools as follow:

• Open edX Studio (Authoring tool)

• The Open edX LMS (Learning Management System)

• The capa_module XBlock, which implements a set of problem types that are based on LON-CAPA problem types

• The ORA2 XBlock, which implements an open response assessment problem type

• Discussion forum

• Open edX Insights

Open edX Studio is the tool that allows building the MOOC content. On the first stage Studio allow to build the structure of the micro-MOOC, then add content to it, include problems, videos, and other learning resources. In addition to above, through the Studio educator can manage the created content – publish it, establish schedule, set the grading scale, and so on.
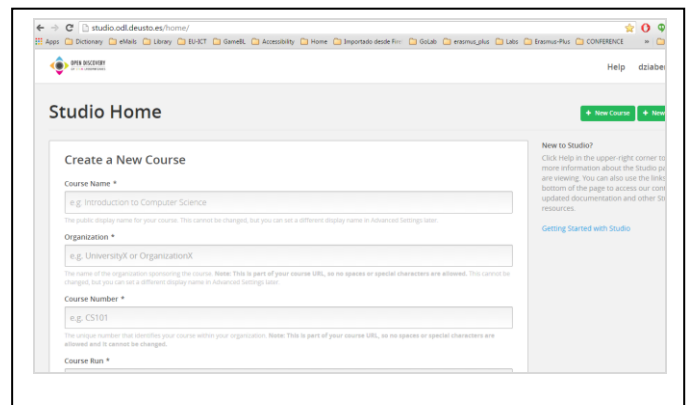

Fig. 2. Open edX Studio: Create a New Course

The Studio is totally online tool and need only browser to access to it (Figure 2).

Open edX LMS is the instrument to access course content, including videos, textbooks, and problems, and to check their progress. The social tools such as discussion forum and a wiki are introduced over the LMS as well.

For content-developers team, the LMS provided an Instructor Dashboard, with options to enroll learners, produce reports, and administer a running course.

XBlock is the component architecture for the elements of Open edX. This tool allows to make different components in online content compatible. XBlocks can be built to represent as small content structures such as individual problems, text strings, HTML content and larger ones such as lessons, sections, and entire courses. Using the different types of XBlocks (texts, videos, problems, virtual and remote laboratories, collaborative spaces) the mMOOC team of developers/teachers can create rich and engaging learning content for students.

Moreover, XBlocks are deployable in any instance of the edX Platform, and can be used by any teachers' team using that system.

For the test of our idea we used the most recent release of Open edX Dogwood [10]. The edX platform is developed for delivering and development of the MOOC of university education. Because of this the detailed testing of all available instrument were performed and only those that fit to the purpose of the secondary school level of education will be used in frame of ODL MOOC platform [11].

The total list of available instruments provided by the edX platform includes more than 50 items. Some of them devoted exclusively to university curricular. Those were rejected from the list of components offered to school teachers. The chosen tools list includes:

- Library
- Annotation Problem: highlighted test and question/assignment to this part of the text
- Calculator
- Checkbox with provided Feedback
- Problem with an Adaptive Hint
- Open Response Assessments
- Drag and drop problem (will be available only for PC)
- The full screen image tool: students can enlarge the image and see all the detail in context
- Google Drive documents, Hangouts
- Periodic Table Tool
- Problem Written in LaTeX: teacher should know the basic LaTeX language OR Create a Math Expression
- Randomized Content Block

- Recommender Tool: provided the online recommended tools, such as khan academy, open education resources, etc.
- Chemical Equation Problem
- Text Input tool: fill blank field
- iFrame tool
- File uploading
- Audio & Video. The best way to use Youtube collection of videos
- Course updates and handouts
- WIKI for students

The students have an open access to a catalog of all available learning materials on ODL platform. The registered student has an overview the courses enrolled using the dashboard (Figure 3).
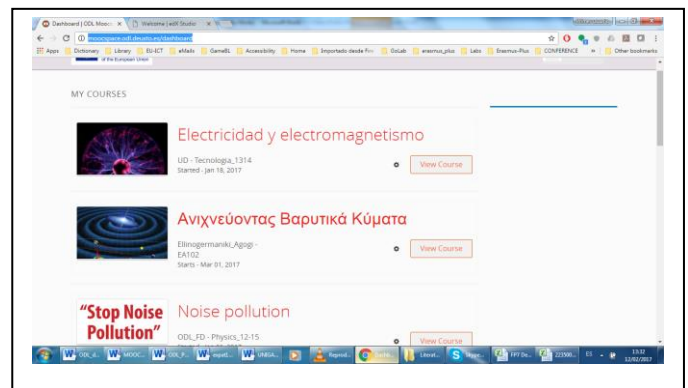

Fig. 3. ODL MOOC Platform - LMS: Student's dashboard with enrolled "courses"

Besides of this the platform provides the collection of the teaching and learning resources that could be helpful for design of education materials; the lessons scenarios; the contacts to the leader in each country and the help area. In the ODL education resources catalogue we keep the created by edX developers' team "edX Demonstration course" as a valuable instruction for those who would like to mastery their platform experience.

IV. MICRO-MOOC IN ODL

Exploring the MOOC idea in school context, the consortium determined that based on the content-load, activity and time consuming, it would be beneficial to chunk the MOOC course on few small teaching materials – micro-MOOCs (activity for around 40 min in the classroom). Usually, course consists of several lectures. Each lecture in format of micro-MOOC includes a laboratory work, theoretical and practical content, assessment and discussion. The discussion or social learning is valuable part of MOOC methodology to allow mastering students' understanding a problem, communication with peers, formulation of the goal, task, and question, brief and clear answering the peer questions. Such function of the methodology offers creating the transversal pupils skills in STEM classes.

Below the example of the mMOOC structure (time schedule) is presented.

TABLE I.   TIME SCHEDULE FOR A LESSON WITH MICRO-MOOC

Phase	Description	Time	Total time (min-max)
1	Topic Introduction	1-3 min	1-3
2	Student **Engagement** and Motivation	4-6 min	5-9
3	Initial **Exploration** of the virtual/remote Lab	3-6 min	8-15
4	Questioning - Stimulating curiosity	2-4 min	10-19
5	Performing virtual experiments I	2-5 min	12-24
6	Questioning - Stimulating reasoning	2-4 min	14-28
7	Performing virtual experiments II	2-5 min	16-33
8	Questioning – Providing reasonable **explanations**	2-4 min	18-37
9	Performing virtual experiments III	2-5 min	20-42
10	Questioning – Providing concluding remarks	2-5 min	22-47

Indeed, teacher can and should modify and adapt it for own professional habits, aiming what they want teach, how support weaker students, and offer extension activities for stronger students while using the same core materials.

In this paper we are presenting the micro-MOOC created for introducing to school students the topic "Resistors in series connections". The remote experiment VISIR+ on the basis of the WebLab-Deusto [12] was incorporated into the micro-MOOC (Figure 4).
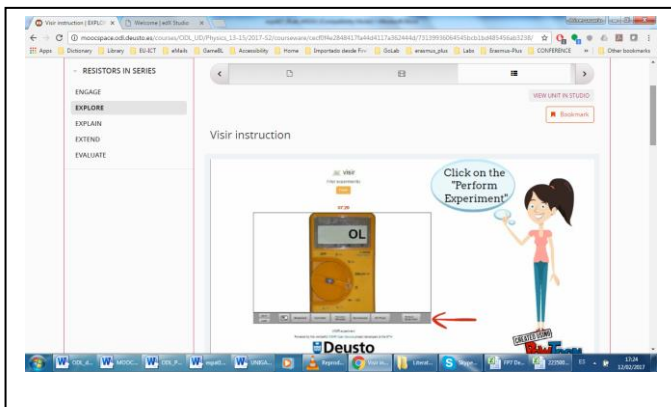

Fig. 4.   ODL micro-MOOC "Resistors in series connections"

We use the 5E cycle (ENGAGE, EXPLORE, EXPLAIN, EXTEND, EVALUATE) of the inquiry scenario to develop student critical thinking, and to help students to explore and evaluate their learning [13].

On very first stage – ENGAGE, we use the video to introduce the resistor as a common element of electrical network and electronic circuits. On the second stage EXPLORE students should perform experiment. The

gateway4labs lab manager was applied to incorporate the remote experiment into ODL MOOC platform. On the EXPLAIN stage student shell demonstrate the understanding the real value of the resistor in the hands-on physical experiment or in real world. The fourth stage EXTEND enforces the students to create the mathematical model for N resistors in series, understanding that the value of the 2 resistors in series is the sum of these two resistors. During the EVALUATE stage the students are asked to design 5 meaningful questions to their classmates to evaluate if they understood the topic. Such activity will (1) monitor in creative way whether students, asking and answering questions, understood topic; (2) teach students to formulate the assignment; (3) evaluate the response and provide feedback to peers; (4) work in a team tolerantly and responsible.

With such action, the ODL team wants to encourage young students to acquire scientific inquiry skills, to experience the culture of performing and of debating on science under motivation of undertaking active and guided experimentation. As a result the students will be engaged in science carrier.

V. CONCLUSION

This paper presents the successful implementation remote experiment in the micro-MOOC format for school sector. The micro-MOOC approach allows using *open inquiry methodology* in class. Depends on the students' level on knowledge and skills, and their awareness of inquiry processes, the 5E stages could be modified and united by the teachers doing their practice fitting to education needs of their students. In micro-MOOC environment 5E cycle is not pedagogical "dogma", but living organism allowing transform the classic lesson in creative education process. In addition to this, the micro-MOOC is *harmonizing tool for delivering the unique content*, created for each student, keeping in mind their previous knowledge and skills as well as learning models. The *communication component* of the MOOC methodology plays crucial role allowing develop by a student transversal competences such as how to formulate their idea and problem solution, to create hypothesis, to participate in debates, to understand classmates, to ask questions and provide clear useful answer, and to work in one team.

Although most of activities of ODL project are still in development stage and it is too early say about the long-term impact of this attempt, it is clear that school teachers have significant interest to use micro-MOOCs in their classroom. They see micro-MOOC as a tool to open a horizon of STEM subjects to their students; to embed the use of remote and virtual labs in the framework of their curriculum, which they never could use otherwise, and to broad their collaboration with the colleagues on multidisciplinary aspects.

Currently, the ODL consortium together with school teachers is building a collection of micro-MOOCs for STEM subjects. The catalog will include at least 60 micro-MOOCs matching with their national school science curricular. The students of high school are also participating in this activity. In autumn semester we are planning to collect and analyze the results of the implementation of the micro-MOOC in school

instruction. For this purpose the feedback and students results of achievements from the platform analytics will be studied.

The data of our trials will be published on the project website (http://opendiscoverylabs.eu/) and on the Facebook group discussion wall. The study results could be helpful for secondary school sector representatives, education instructors, parents and policy makers to respond to current and future education needs.

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