This is a postprint version of the following published document:

Delgado Kloos, Carlos; Alario-Hoyos, Carlos; Estévez-Ayres, Iria; Muñoz-Merino, Pedro J.; Ibáñez, Mª Blanca; Crespo-García, Raquel M. (2017). Boosting Interaction with Educational Technology. *Proceedings of 2017 IEEE Global Engineering Education Conference (EDUCON2016), 25-28 April 2017, Athens, Greece*, pp.: 1763-1767.

DOI: https://doi.org/10.1109/EDUCON.2017.7943088

Boosting Interaction with Educational Technology

Carlos Delgado Kloos, Carlos Alario-Hoyos, Iria Estévez-Ayres,
Pedro J. Muñoz-Merino, Mª Blanca Ibáñez, Raquel M. Crespo-García
Dep. Telematic Engineering, Universidad Carlos III de Madrid, 28911 Leganés (Madrid/Spain)
{cdk, calario, ayres, pedmume, mbibanez, rcrespo}@it.uc3m.es

Abstract—**The MOOC movement has helped faculty in focusing on how to lecture. However, once this is done, it would not make sense not to use this content for on-campus classes. In this paper, we will explain how to harness top content created for MOOCs to improve on-campus classes, where the personal interaction is a key added feature. Interactive practices and on-site interaction, especially in-class interaction, are of particular relevance in the evolution of Higher Education towards a more effective learning.**

Keywords- MOOCs, SPOCs, interaction, Higher Education

I. SHORT DISTANCE EDUCATION

Technology allows overcoming distance in educational settings. Therefore, distance education makes intensive use of digital technologies. In a distance-learning context technology is a must [1]. However, this does not mean that technology cannot (and should not) also be used in other contexts. It is like saying that trains are only useful for long distance, even though in many cities trains are used to travel in the short distance.

As a matter of fact, it turns out that educational technology is very useful in the classroom [2]. Even in a lecture hall, where students and professors share a common space, interaction can be greatly enhanced with technology. And it is interaction that matters, not being together in a common space [3].

The MOOC (Massive Open Online Course) movement has helped faculty in focusing on how to lecture [4]. The pressure to teach to a worldwide, diverse audience has helped in trying to explain things in the best possible way that is understandable by all. However, once this is done, it would not make sense not to use this content for on-campus classes [5], as the so-called SPOCs (Small Private Online Courses) [6].

Digital technologies allow three relevant things in education:

- instruction without physical interaction,
- interactive practice and
- on-site interaction (particularly in-class).

Clickers were an early device for enhancing interaction in the classroom [7], but now the pervasiveness of smartphones allows using these devices as an additional communication channel of students with instructors and among students [8].

This paper aims to explain how to harness top content created for MOOCs to improve on-campus classes, where the personal interaction is a key added feature. The remaining of this paper continues discussing instruction without physical interaction. Then, examples of interactive practices are presented. On-site interaction strategies to be applied, particularly in-class, are discussed. Finally, the paper draws some conclusions.

II. INSTRUCTION WITHOUT PHYSICAL INTERACTION

The advent of MOOCs has brought important changes to Higher Education. Courses from high-level Universities are, suddenly, available to any learner willing to learn and, moreover, MOOCs can be brought into the campus (SPOCs), contributing to an improvement on the quality of more traditional courses [9]. In this way, the whole content of a MOOC can be used as a complement of traditional lectures or as a replacement of these traditional lectures in a flipped classroom approach [10].

A MOOC typically includes learning sequences with videos and activities, both formative and summative. On-campus instruction can take advantage of this richness of content using it for different purposes. For example, the less interactive content, such as videos or multiple choice exercises, can be used to reinforce (or even substitute) some explanations on a traditional course, thus allowing leveraging the "quality time" of professors as they can focus on more difficult concepts or on resolving doubts about the concepts already explained in those videos [11].

However, a MOOC is much more than videos and multiple-choice activities. A MOOC has also a strong practical component, which comprises different and meaningful interactive exercises that can also be used in a more traditional setting. Main MOOC platforms provide different types of exercises, from quizzes to peer assessment. Many of these platforms also support the integration of external tools (through the usage of e.g., LTI [12], or embedding exercises into HTML). Main MOOC platforms are intensively working in increasing the range of activities that can be used in these courses. Examples of these tool include automatic code correction in some languages for programming courses, which are among the most demanded MOOCs by learners [13].

Through the usage of MOOCs, the teaching staff can offer several types of exercises to learners. Thus, their learning experience is also enriched, as learners can follow a path that leads them from simpler exercises (such as quizzes or a multiple choice question) to more complex ones (e.g., writing a piece of code, or designing an electronic circuit) strengthening their knowledge in the process. Moreover, the virtually instant grading and feedback provided by many of those tools integrated within MOOC platforms alleviates the professor from routine tasks, such as grading formative tests, and the interaction with the students can be enriched with deeper and more exhaustive explanations about difficult concepts [14].

Additionally, the huge variety of different exercises allows reaching students with many different learning styles, as one concept can be reinforced by different exercises, each targeted to a different audience [15]. This huge range of possibilities is often not possible in traditional settings, where the time is limited and even the more willing professor is only able to solve a subset of the different exercises, or reinforce only part of the concepts explained in each lesson; this forces, in many cases, students to move forward into the subject without mastering the prior (and needed) concepts. By offering different types of exercises in the MOOC platform, students can train and review concepts at any time during the course (going back and forth through the available MOOC content).

III. Interactive Practice

One of the biggest challenges in a MOOC (or SPOC) is to create the content with sufficient quality so as to enable the student to effectively self- learn the subject matter [16]. A key aspect to consider is the learning strategy quality, which must be aligned with contemporary theories of learning and instruction. In these theories, the emphasis is toward more learner-centered instead of teacher-centered instruction. This tendency has led to new approaches to the design of instructional environments. One of these new approaches is discovery or exploratory learning within computer simulation environments.

According to [17], a computer simulation is "a program that contains a model of a system (natural or artificial; e.g., equipment) or a process". The main advantage of simulations is that they provide a constrained environment to explore by learners. This constrained environment defines a set of variables that the user can manipulate and observe as determined by the designer. In comparison with other learning objects, a computer simulation allows students to explore hypothetical situations, interact with a simplified version of a process or system, practice tasks and solve problems in a realistic environment without stress.

The potential benefits of discovery learning is that knowledge discovered by the learner will be based more firmly in the learner's knowledge base and is more related to the learner's prior knowledge than knowledge that is just told or read. Computer based simulators can be used as embedded learning objects in a MOOC [18], or for an active learning experience where the learning materials of the MOOC were studied before class [19]. When learners possess the skills that are needed to carry out the discovery learning, they will be motivated, and they will achieve the learning outcomes expected. However, when learners experience problems with these methods, which is often the case, support must be provided [20].

IV. On-Site Interaction

The evolution of technologies has made it possible to implement in a very cheap way pedagogical approaches that foster actual on-site interaction, but that were sometimes discarded because they required a lot of resources and were complex to orchestrate. One of such examples are voting systems. Clickers have been used in education for decades to ask questions to students on-site, so that the teachers can know if they understood to explanation and adapt the rest of the class on the fly depending on students' answers [7]. However, clickers required special classes or devices that were not always available and required expensive maintenance [21].

Mobile technologies have facilitated the development of tools such as Kahoot! [22], Quizalize [23], Quizizz [24] or Mentimeter [25], which carry out polls, in a similar way that it was done with clickers in the past, but from mobile devices. The fact that students carry mobile devices (smartphones, tablets…) with them to the classroom facilitates the orchestration of on-site interaction through polls with the aforementioned tools, avoiding the high maintenance costs that clickers used to have.

Traditional face-to-face class sessions can be enhanced with on-site interactions driven by technology. These on-site interactions can be classified depending on different criteria. We provide four different categories for this classification.

- The first classification refers to the use of technologies for on-site interactions between those which are a complement for existing traditional activities and those which are stand-alone activities. For example, a teacher's presentation can be complemented with students' answers to a question posed by the teacher and related to that presentation. These types of interactions enrich existing activities. In contrast, there are activities which are stand-alone, such as playing an educational computer-based game aimed at answering different questions. Both types of activities can coexist in the same classroom.
- The second classification considers the main purpose of the on-site interaction. Taking into account this criterion, interactions can be divided in e.g., surveys, answering questions, solving problems, etc.
- The third classification focuses on the methodology used. Methodologies include e.g., gamification techniques, educational games, learning analytics or social learning.
- The fourth classification distinguishes commercial solutions from research prototypes. Commercial solutions are usually intended for a wide group of cases, while research prototype solutions are usually more specific for addressing particular problems.

Next, there are several examples of tools that enable on-site interactions:

- Kahoot! [22]. This tool allows teachers to create and select a set of multiple-choice questions. These questions are provided to students in a projector in a synchronous way during the class sessions. The students can see the questions and the possible solutions, answering them from their mobile devices. The students should solve the questions in-live competing with other students in a gamified way. Results are displayed on screen typically through bar charts.

- Quizalize [23]. This tool enables students to answer some questions while making other on-site activities. It provides a powerful learning analytics support, which enables teachers to detect global problems in the classroom or specific issues with some students.
- Quizizz [24]. This tool also enables teachers to create and select some questions (typically multiple-choice questions) that students have to answer. Each student receives his own questions, but not all students are solving the same question at the same time. This makes it possible different paces in the classroom. Gamification and competition can also be enabled.
- Mentimeter [25]. The tool enables to create surveys that can be answered by students during a class session, e.g., during a PowerPoint presentation.
- ShopC [26]. This is an educational computer board game inspired by the Monopoly game. The objective is not to run out of money while making opponents run out of money. Students can buy properties and receive money when other students go into their properties. The amount of money spent or received depends on how students solve different questions that are proposed.
- ISCARE [27]. This tool enables competition among students in pairs in different rounds. The opponents, as well as the questions for each round, are selected in an adaptive way to pair students with the same level, and to assign contents adapted to each student. Students are provided with leaderboards and can follow the opponent activity on-live.
- MagicLearning [28]. This tool introduces students in a magic world in which they should battle with monsters and get objects (e.g., a sword or a crown); these objects have different powers that can be used in the game. The number and type of objects achieved depend on the performance of the student when answering questions.

Table 1 shows a classification of these tools according to the four classifications categories proposed in this section. Each tool has at least a value for each classification category, but can have several values for the same category, e.g., gamification and learning analytics.

There are several advantages of introducing technologies and tools that enable on-site interactions. For example, they allow for an easy seamless integration of gamification techniques, which can help to increase learners' engagement in the course. Furthermore, these technologies and tools usually include learning analytics features, which serve teachers to get more information about what is happening in the course and intervene appropriately, adapting the pace of face-to-face traditional interaction.

V. In-Class Interaction

MOOCs help to reduce the time devoted to lecturing, since students can work the basic content, usually through short video lectures, from their homes, and before arriving at the classroom. It is even possible to completely eliminate lectures from classes on campus following the model so-called "flipped classroom" [10], [29]. The time that was formerly used to lecture can be now devoted to promoting in-class interaction using different approaches and pedagogies. Examples of approaches and pedagogies that can foster interaction, and that can be applied in the classroom are active learning, collaborative learning, inquiry-based learning, or project-based learning, among others. Such approaches and pedagogies can also contribute to the development of soft skills, such as collaboration skills, critical thinking skills, presentation skills, or leadership skills, which are among the most demanded ones by employers. In general, the flipped classroom model allows working in the lower levels of the Bloom's taxonomy before going to the classroom (remembering and understanding), while working in the upper levels of the Bloom's taxonomy in the class (applying, analyzing, evaluating and creating).

The use of MOOCs (and SPOCs) to implement flipped classes and promote in-class interaction has meant several success cases. Next, we report on two different success scenarios implemented at UC3M.

First, UC3M has applied SPOCs and the flipped classroom model in remedial courses in Physics, Mathematics and Chemistry, i.e. courses for leveraging students who access a first-year degree at UC3M. At the beginning students interacted with the educational content from home, watching videos or solving exercises; next students went to face-to-face sessions for more active learning activities. Different indicators revealed a successful experience using this methodology in Physics in 2013 [30]. In addition, learning analytics tools, such as ALAS-KA [31], were introduced in these remedial courses with the aim to enable teachers to gain insights about their students, and make decisions to adapt the pace and explanations in the face-to-face sessions. As an example, a precise metric for the calculation of the effectiveness of learners with videos and activities was proposed in order to help teachers adapt the learning process in the classroom based on these metrics [32].

Tool	**1st class.**	**2nd class.**	**3rd class.**	**4th class.**
Kahoot!	Stand-alone	Question solving	Gamification	Commercial
Quizalize	Complement	Question solving	Learning Analytics	Commercial
Quizziz	Complement	Question solving	Gamification	Commercial
Mentimeter	Complement	Survey	Gamification	Commercial
shopC	Stand-alone	Question solving	Gamification Games	Research prototype
ISCARE	Stand-alone	Question solving	Gamification Competition Learning Analytics	Research prototype
MagicLearning	Stand-alone	Question solving	Gamification Games	Research prototype

Table 1: Classifications of tools that enable on-site interactions, according to four different categories: use (1st class.), purpose (2nd class.), methodology (3rd class.), technological readiness (4th class.)

Second, UC3M has piloted flipped classroom in several courses by reusing MOOCs that were previously offered to anyone in the world in the platforms MiríadaX [33] or edX [34]. Actually, the number of courses using this approach are expected to increase in the next years. It is worth noting the outcomes of a course called *Elasticity and Strength of Materials*. This is a difficult engineering course with the lowest passing rate in the degree in which it is delivered. This course managed to reach the average number of passing students in the degree after applying flipped classroom (supported by the reuse of a MOOC) and in-class interaction. For this course, large-group lectures were fully replaced by problem solving by the teacher. And small-group classes, which were before used for problem solving by the teacher, were used to solve complex problems in large groups. This meant a better preparation of students for the final exams, and greater motivation. In addition, this in-class interaction contributed to foster the acquisition of soft skills such as collaborative work, leadership, and presentation skills, as students had to present their solution to their peers at the end of the class.

VI. CONCLUSION

MOOCs have changed the way in which courses are taught by Universities, both to the world (outside the campus), and to residential students (within the campus). This change, which in a first stage only affected content production (particularly focusing on video lecture), has evolved in a second stage towards reusing those high quality contents within the campus to complement (or even replace) traditional lectures or to completely redesign the teaching and learning experience. This new time gained to traditional lecturing is being used to promote interaction, to apply student-centered methodologies, and to foster the development of soft skills.

Technology is permeating the classroom and is the cornerstone to promote interactive practice, on-site interaction, and in-class interaction, reshaping instruction and the learning process. Mobile devices, wearable computing, as well as traditional computers, can provide either transparent or complementary interaction and communication channels, which improve, enrich, and speed up feedback provision [35]. Technology-mediated interaction allows also keeping track of students' (and even professors') activity and interactions too, both inside and outside the classroom. Learning analytics and educational data mining allow thus extracting useful and actionable information from such datasets. Both the professor and the students themselves can benefit of such information to improve awareness, enhance orchestration, and, in general, get a more accurate picture of the learning progress and facilitate more effective guidance for the students to achieve the expected learning outcomes [36], [37], [38]. Analogously to what has happened in other areas, in which the quantified self helps the user to first discover and understand, next motivate, and finally change or reinforce habits, behaviors and activities, it is logical to expect it to support students in a similar manner in their learning process.

MOOC technology is following to some extent the SAMR model developed by R. Puentedura [39]. This model offers a model of seeing how technology might impact teaching and learning. SAMR stands for Substitution, Augmentation, Modification, Redefinition. The final step, the one of redefinition, allows to design completely new learning experiences that where not possible without MOOC technology.

ACKNOWLEDGMENT

The eMadrid Excellence Network is being funded by the Madrid Regional Government (Comunidad de Madrid) with grant No. S2013/ICE-2715. This work also received partial support from the Spanish Ministry of Economy and Competitiveness, Project RESET (TIN2014-53199-C3-1-R) and fellowship FPDI-2013-17411, and from the European Commission through Erasmus+ projects MOOC-Maker (561533-EPP-1-2015-1-ES-EPPKA2-CBHE-JP) and SHEILA (562080-EPP-1-2015-1-BE-EPPKA3-PI-FORWARD).

REFERENCES

[1] M. J. Rosenberg, WE-learning: Strategies for delivering knowledge in the digital age". Vol. 3. New York: McGraw-Hill, 2001.

[2] T. Levin, W. Rivka, "Teachers' beliefs and practices in technology-based classrooms: A developmental view." Journal of Research on Technology in Education 39(2), 157-181, 2006.

[3] A. B. Tsui, "Classroom interaction." The Cambridge guide to teaching English to speakers of other languages, 120-125, 2001.

[4] P. J. Guo, K. Juho, R. Rob, "How video production affects student engagement: An empirical study of MOOC videos." Proceedings of the first ACM conference on Learning@ scale conference. ACM, 41-50, 2014.

[5] F. G. Martin, "Will massive open online courses change how we teach?." Communications of the ACM, 55(8), 26-28, 2012.

[6] A. Fox, "From MOOCs to SPOCs." Communications of the ACM, 56(12):38-40, 2013.

[7] A. R. Trees, H. J. Michele, "The learning environment in clicker classrooms: student processes of learning and involvement in large university-level courses using student response systems." Learning, Media and Technology 32(1), 21-40, 2007.

[8] D. Méndez, S. Josip, "Software Socrative and smartphones as tools for implementation of basic processes of active physics learning in classroom: An initial feasibility study with prospective teachers." European Journal of Physics Education 4(2), 2013.

[9] R. J. Griffiths, M. M., Chingos, R. Spies, C. Mulhern, "Adopting MOOCs on Campus: A Collaborative Effort to Test MOOCs on Campuses of the University System of Maryland." Online Learning Journal, 19(2), 2014.

[10] J. P. de la Croix, M. Egerstedt, "Flipping the controls classroom around a MOOC." Proceedings of the American Control Conference 2014, ACC, 2557-2562, 2014. IEEE.

[11] A. Roehl, S. L. Reddy, G. J. Shannon, "The flipped classroom: An opportunity to engage millennial students through active learning." Journal of Family and Consumer Sciences, 105(2):44-49, 2013.

[12] IMS Global Consortium, IMS Global Learning Tools Interoperability Implementation Guide, Version 1.2. Retrieved from: http://www.imsglobal.org/lti/

[13] L. Pappano, "The Year of the MOOC." The New York Times, 2(12), 2012.

[14] J. Kay, P. Reimann, E. Diebold, B. Kummerfeld, "MOOCs: So many learners, so much potential." Technology, 52(1), 49-67, 2013.

[15] F. Grünewald, C. Meinel, M. Totschnig, C. Willems, "Designing MOOCs for the support of multiple learning styles". In Proceedings of the 8th European Conference on Technology Enhanced Learning, EC-TEL 2013, 371-382, 2013. Springer Berlin Heidelberg.

[16] O. Balci, D. D. Kirby, N. Anderson, "Challenges in teaching modeling and simulation online." In 2013 Winter Simulations Conference, WSC, 3568-3575, 2013. IEEE.

[17] T. de Jong, W. R. Van Joolingen, “Scientific discovery learning with computer simulations of conceptual domains,” Review of Educational Research, 68(2):179-201, 1998.

[18] F. García, G. Díaz, M. Tawfik, S. Martín, E. Sancristobal, M. Castro, “A practice-based MOOC for learning electronics.” In 2014 IEEE Global Engineering Education Conference, EDUCON, 969-974, 2014. IEEE.

[19] Y. J. Dori, J. Belcher, "Learning electromagnetism with visualizations and active learning." Visualization in science education. Springer Netherlands, 187-216, 2005.

[20] M. B. Ibáñez, A. Di Serio, D. Villarán-Molina, C. Delgado-Kloos, “Support for Augmented Reality Simulation Systems: The Effects of Scaffolding on Learning Outcomes and Behavior Patterns”, IEEE Transactions on Learning Technologies, 9(1), 46-56, 2016.

[21] M. Bugeja, "Classroom clickers and the cost of technology." Chronicle of Higher Education 55(15):A31, 2008.

[22] Kahoot, getkahoot.com

[23] Quizalize, quizalize.com

[24] Quizizz, quizizz.com

[25] Mentimeter, mentimeter.com

[26] M. Julian-Mateos, P. J. Muñoz-Merino, D. Hernández-Leo, D. Redondo-Martínez, C. Delgado Kloos, “Design and Evaluation of a Computer Based Game for Education.” In Frontiers in Education Conference, FIE, 1-8, 2016. IEEE.

[27] P. J. Muñoz-Merino, M. Fernández Molina, M. Muñoz-Organero, C. Delgado Kloos, “An Adaptive and Innovative Question-driven Competition-based Intelligent Tutoring System for Learning.” Expert Systems with Applications, 39(8):6932-6948, 2012.

[28] P. J. Muñoz-Merino, C. Delgado Kloos, M. Muñoz-Organero, “MagicLearning: A Serious Game for Learning Based in a Magic World.” International Journal of Innovative Control Information and Computing, 8(11), 7781-7791, 2012.

[29] J. Bergmann, A. Sams, “Flip your classroom: Reach every student in every class every day.” International Society for Technology in Education, 2012.

[30] P. J. Muñoz-Merino, J. A. Ruipérez-Valiente, C. Delgado Kloos, M. A. Auger, S. Briz, V. de Castro, S. N. Santalla, “Flipping the classroom to improve learning with MOOCs technology.” Computer Applications in Engineering Education (in press), 2016.

[31] J. A. Ruipérez-Valiente, P. J. Muñoz-Merino, D. Leony, C. Delgado Kloos, “ALAS-KA: A learning analytics extension for better understanding the learning process in the Khan Academy platform.” Computers in Human Behavior, 47:139-148, 2015.

[32] P. J. Muñoz-Merino, J. A. Ruipérez-Valiente, C. Alario-Hoyos, M. Pérez-Sanagustín, C. Delgado Kloos, "Precise effectiveness strategy for analyzing the effectiveness of students with educational resources and activities in MOOCs." Computers in Human Behavior, 47:108-118, 2015.

[33] UC3M MiríadaX, miriadax.net/web/universidad-carlos-iii-de-madrid

[34] UC3M edX, edx.org/school/uc3mx

[35] I. Gutiérrez Rojas, R. M. Crespo-García, C. Delgado Kloos, “Orchestration and feedback in lab sessions: improvements in quick feedback provision.” In 6th European Conference on Technology Enhanced Learning, EC-TEL 2011, 424-429, 2011.

[36] I. Gutiérrez Rojas, R. M. Crespo-García, “Towards efficient provision of feedback supported by learning analytics.” In 2012 IEEE 12th International Conference on Advanced Learning Technologies, 599-603, 2012. IEEE

[37] I. Gutiérrez Rojas, R. M. Crespo-García, C. Delgado Kloos, “Enhancing orchestration of lab sessions by means of awareness mechanisms.” In 7th European Conference on Technology Enhanced Learning, EC-TEL 2012, 113-15, 2012.

[38] C. Delgado Kloos, A. Pardo, P. J. Muñoz-Merino, I. Gutiérrez, D. Leony, “Learning Analytics @ UC3M.” In IEEE Global Engineering Education Conference, EDUCON 2013, 1232-1238, 2013.

[39] SAMR Model. https://sites.google.com/a/msad60.org/technology-is-learning/samr-model