MOOC FOR MATHEMATICS TEACHER TRAINING: DESIGN PRINCIPLES AND ASSESSMENT

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This paper reports on an ongoing international research about MOOCs for in-service mathematics teacher training. We describe and analyse two different experiences of this kind: the Italian MOOC Geometria and the French MOOC eFAN Maths. Both MOOCs aimed at supporting the teachers' professional development through a suitable mediation of technology and at triggering as much as possible the teachers' engagement so that they could develop from a non-community towards one or more communities of practice. As authors of this paper, we are members of the trainers' team of the respective MOOCs and we also participated in the design. Starting from our methodological choices, we want to propose some reflections about design principles of MOOCs for mathematics teacher training in order to foster participation and collaboration among trainees and to efficiently assess this kind of engagement.

Keywords: MOOC, design principles, project-based assessment, completion rate

INTRODUCTION

The Massive Online Open Courses (MOOCs) are becoming widespread as a training tool in universities (Pomerol et al., 2015) and management institutions (Porter, 2015) and also for in-service teacher training, but not so much for mathematics teacher training.

Our paper describes and analyses a double experience gained in France and in Italy with MOOCs of this kind, delivered to mathematics teachers, mainly from secondary schools, with the aim of increasing their professional competencies and improving their classroom practices.

In fact, there are at least three main problems in MOOCs: (i) How to trigger an active participation? (ii) How to assess in a trustable way the efficiency of the MOOC? and (iii) What type of technology is better to use in order to get as positive results as possible in the previous two points? This last issue assumes a specific connotation in the case of mathematics teachers. Our paper shows that there are different ways to catch the interest of trainees and we explore, compare and discuss them considering two different design approaches.

For the assessment issue, a first crude evaluation estimate consists in considering the drop-out rate. The literature suggests a mean of 95% rate (Bayne & Ross, 2013). In our cases the figures are completely different: in France it was about 88% (second experience), and in Italy 64% (first experience). In other joint papers (Taranto et al., submitted chapter; Panero et al., 2017; Taranto et al., 2017) we have described how a subtler analysis can help to develop a more sophisticated assessment of the level and nature of participation in a MOOC for in-service mathematics teacher training.

For the technology, we sketch how some 2.0 open source devices and software or professional social network, suitably organized and exploited, can trigger and support an active participation of the trainees in the MOOCs activities.

Based on the analysis of the two experiences our paper faces the following two research questions:

(i) What design principles are useful to mediate teachers' professional development courses with technology?

(ii) How to assess the impact of such courses on mathematics teachers' engagement?

AIMS AND DESIGN PRINCIPLES OF MOOC

In this section we explain the specific aims of each MOOC. They have been achieved taking into consideration precise methodologies and design principles: (i) promote educational innovation; (ii) stimulate reflection on the use of technology in the classroom and with the students; (iii) create communities of practices (Wenger, 1998) and support the sharing.

Italian MOOC: The MOOC Geometria

MOOC Geometria is a MOOC on Geometry, for training in-service mathematics teachers of secondary school (both lower and higher). 424 participants enrolled in it, all teachers in secondary school, from all over Italy. It was delivered on a Moodle platform called DIFIMA[1] during 8 weeks: from October 2015 to January 2016. MOOC Geometria was designed by experienced teachers of secondary school in collaboration with some researchers in Mathematics Education from the Department of Mathematics of Turin University; the same team took care of delivering the course. These experienced teachers were trained in Mathematics Education and in innovation basing on the didactical material of the m@t.abel project (https://goo.gl/Q30Dn0), a plurennial National Program that pushed innovation in mathematics teaching basing on concrete activities proposed to teachers and discussed with them in suitable training e-courses. The following needs had been identified: awareness of the role of training in teaching activities; willingness of developing best practices of innovation using software; reconsidering in terms of learning the sharing practices of social media most used by the students. Hence, it was decided to offer the opportunity of an authentic development experience designed for a larger group of teachers that could have become a community of practices (Wenger, 1998): that is the idea of the Italian MOOC Geometria.

In particular, five specific modules on geometric contents were created. The activities had a weekly basis and the duration of each section varied from 1 to 2 weeks (depending on the treated topics). All the activities are based on mathematics laboratory and MERLO[2] assessment tools. As pointed out above, they are inspired by m@t.abel project and are transposed in a digital format following the E-tivity framework (Salmon, 2013). The E-tivity are designed before opening the MOOC to participants. They provide learners with an effective scaffolding to support them in achieving the learning outcomes: in fact, they promote a learner-centred task and problem-based approach to online learning (moving away from content-centric design) and find easily purposeful ways of using freely available, topical and/or game-based resources within the learning design.

[1] DIFIMA: Didactics of Physics and Mathematics (http://difima.i-learn.unito.it/), hosted by the Department of Mathematics of Turin University

[2] MERLO: Meaning Equivalence Reusable Learning Object (Arzarello et al., 2015)

To motivate participants to contribute and consolidate ideas in a focused way, and, at the same time, to collaborate and communicate, specific technological tools were selected. There are only open source tools in the MOOC (e.g. Geogebra, Dynamic Geometry System), thus respecting the Open in the MOOC acronym and, above all, enabling teachers to easily fit in with them in their teaching practices. In the design we took into account also the TPACK model (Mishra & Koehler, 2006) with the intention of enlarging the mathematical technological knowledge of the trained teachers. In particular, with respect to the 7Cs (Conole, 2014), a great attention was given to "Communicate" and to "Collaborate", focusing on the choice of the best tool to be used both for a catchy and easy online access presentation of a selected content and for supporting the communication and collaboration among the participants in the course. In fact, specific communication message boards from web 1.0 to web 2.0 were selected (Forum, Padlet - https://it.padlet.com/, Tricider - https://www.tricider.com/). Trainers reduce their interventions in this space as much as possible for fostering the development of an interactive only-trainees community. However, trainers were "behind the scenes": they sent weekly emails to inform all participants about the progress of their experience training; they also intervened when technical problems came up (sometimes even with an email to a single person). Real moments of contact with the trainees were the three webinars. They are online meetings in which an expert shares with the participants some issues about the research in mathematics education and focuses on some questions that could be raised during the previous weeks in the MOOC. During the webinars the participants had the opportunity of taking part in a chat in synchronous way. All of the three webinars had a high participation (from 90 participants in the first one to 50 in the last one) and consensus by the trainees, who posed many questions and doubts.

French MOOC: MOOC eFAN Maths

MOOC eFAN Maths (*Enseigner et Former avec le Numérique en Mathématiques – Teach and train with digital technology in mathematics*) is a MOOC about teaching mathematics with technology, for training in-service mathematics teachers and teacher educators, particularly from secondary school. The second season of the MOOC eFAN Maths was delivered on the French MOOCs national platform, called FUN (*France Université Numérique*) from the 8th of March to mid-April 2016. The MOOC eFAN Maths was organised in five weeks, each proposing three video-lessons on key concepts of technology in mathematics education, one multiple-choice test per lesson, an activity related to the theme of the week and a few articles for in-depth study. The examples discussed in the video-lessons were selected and adapted from different European research projects (e.g., FaSMEd[3], MC Squared[4]) with a focus on the use of technology supporting formative assessment and enhancing creative mathematical thinking.

The trainers were also members of the designers' team of the MOOC, composed of experienced secondary school teachers and researchers in Mathematics Education working at the Ifé (French Institute of Education) of the Ecole Normale Supérieure de Lyon. The designers were motivated by a double institutional aim: to support teachers and teacher educators in understanding and implementing the new French curriculum (applicable since September 2016 in all French primary and secondary schools) and to promote collaboration within the French-speaking mathematics education community.

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[3] Formative Assessment in Science and Mathematics Education (fp7/2007-2013 grant agreement n.612337).

[4] Mathematical Creativity Squared (ICT-2013.8.1 "A Computational Environment to Stimulate and Enhance Creative Designs for Mathematical Creativity", Project 610467).

The designers' methodological choices can be explained according to some of the "pillars of an accompanied auto-training" introduced by Carré (2003). Inspired by these pillars, the designers tried to manage and equilibrate the interplay of the *individual project* with which each trainee enrols in a training, the *pedagogical contract* between trainers and trainees, the trainees' *pre-training* to use some particular tools (such as the possibility to access tutorials), the role of the *trainer as a facilitator*, and the presence of an *open environment*. The designers provided an open environment to encourage trainees' participation in the training. Only free open-source tools were presented, so that teachers could easily find and appropriate them. Moreover, to foster collaboration between trainees, they were invited to join a professional social network for teachers, called Viaéduc (www.viaeduc.fr), where trainees could gather together around a shared project constituting public groups (so that any trainee could read the work of any other group and follow any discussion). Some trainers worked as community managers: they helped trainees to solve technical problems, such as creating an account on Viaéduc; they made tutorials for using FUN and Viaéduc platforms; they created and regularly updated a list with all the trainees' ongoing projects to help teachers to find a project to join; they recalled the tasks to be done week by week. Furthermore, every week began with a quick video titled "From one week to the other" in order to bridge two consecutive weeks of the MOOC. Finally, to cultivate and induce the generation of trainees' groups as communities of practice, one trainer per group followed the development of the group project from the inside, intervening to encourage and trigger the collaborative work (Panero et al., 2017). This represents also a special condition of the pedagogical contract between trainees and trainers.

The total number of participants enrolled in the MOOC on the FUN platform was 2572, mostly French-speaking mathematics teachers and teacher educators interested in the use of technology. However, only 737 trainees decided to join Viaéduc and work on collaborative projects.

PROJECT-BASED ASSESSMENT

In this section we illustrate the activities expected by the participants in each MOOC. In both MOOCs we chose a project-based methodology for assessing the trainees' participation, but articulating it in different ways, and both turned out to be efficient.

Italian MOOC: Project Work with Learning Designer

Every week the trainees had an individual work and interfaced themselves with methodologies at different levels, in order to collect their weekly badges: watching a video where an expert introduced a conceptual knot of the week; watching a "cartoon video" with some guidelines to carry out the units; reading the geometry activities based on mathematics laboratory (and possibly experimenting them in their classroom). Moreover, they had to use the suitable communication message boards (Forum, Padlet, Tricider) to express opinions about the content of the course, make a comparison between colleagues, and benefit from experiences or ways of thinking of others. There were a collaborative climate and, surprisingly, some of them started to voluntarily share material created by themselves and that they were using in their lessons. This is certainly an aspect that does not occur in a traditional training course.

The MOOC design included as a final module two production activities: the design of a teaching activity (or Project Work, hereafter PW) and the review (or Peer Review, hereafter PR) of a project designed by a colleague. The time available to perform these last activities was two weeks. For all those who took part in all MOOC stages (that is, accomplishing all tasks for collecting all weekly badges and accomplishing the PW and PR), a participation certificate was issued by the Math Department of the University of Turin.

It was not necessary that the PW was experienced in class to carry out a PR: it was an activity to be done remotely, demonstrating teaching competencies and experience. In fact, PW and PR have been designed to give the participants the opportunity to get involved in the MOOC activities in terms of methodology, creativity, and with the aim of sharing and discussing them in the community. Each trainee could choose individually a geometrical theme taking a cue from those of the MOOC or even choosing a new one. A lot of freedom was given in the design of the PW both because as teachers the trainees had surely already had experience with these activities (and we as trainers did not want to influence them) and to give space to their creativity. Moreover, the PW had to be done through a web-based tool, the Learning Designer (hereafter LD) designed by D. Laurillard (2012). LD is a software that guides and encourages the planning of the lesson: it is characterized by a standard format that allows the integration of technologies (the teacher can include links to material that s/he has produced or that is on the net); it allows you to have an overview of the teaching/learning dynamics centered on the student and allows sharing of what you have produced online. In order to familiarize the trainees with LD we created both a video tutorial (suggested via link) and a paper-based tutorial: they were made available two weeks before the opening of the last module. For this tutorial supports we detected 411 readings: these figures show its utility.

It was considered important to ask the trainees to make a PR of a colleague's PW in order to have an analysis from an educational point of view, generated by the eyes of a teacher who had no other aim than the analysis of the asset itself. The instructions for the PR were given in a more specific way compared with the PW. We specified the review criteria to follow, because we wanted to focus attention on the main aspects of each educational intervention and, for the purposes of the MOOC itself, on a conscious use of instruments and of digital software.

The deadline had been announced as "sharp" because we wanted to allow everyone to be able to continue with the peer review. However in the forum dedicated to technical problems, some trainees expressed the need of having more time available to accomplish their PW. As trainers-designers, we are taking this feedback into account for the next season of the MOOC.

In the last module of the MOOC, the participants were asked to complete a final questionnaire: we could so receive a feedback on their experience of distance learning, as well as their impressions about the latest activities (for more information see: Taranto et al., 2016).

French MOOC: collaborative project on Viaéduc

Week by week, the proposed activities aimed to support trainees in the design of a mathematical task integrating the use of a digital tool. The phases of the project design consisted of: a) a description of the mathematical task; b) a toolkit made of digital or non-digital artefacts and resources with the related usage schemes within the designed task; c) an analysis of the students' expected mathematical activity and interactions with the artefacts; d) an analysis of the teacher's role in orchestrating the situation in the classroom.

The activities of the weeks devoted to students' and teacher's role relied on two grids designed, uploaded and commented by the trainers. They helped to analyse the designed mathematical task and the role of technology from the point of view both of the students and of the teacher. They consisted in guiding questions grounded on the instrumental approach (Artigue, 2002, Rabardel, 1995) and on the instrumental orchestration (Trouche, 2004), which were both introduced in the lessons delivered in the corresponding weeks. To encourage collaboration, trainees were invited to work on the proposed activities in a collaborative way, by forming groups around common interests for a mathematical theme on Viaéduc a platform that essentially allows members to post comments, to create groups, to create and publish documents and to comment/recommend/share them. Group members can work collaboratively either asynchronously, being authors of the same online document, or synchronously, writing on the same online collaborative board (*padlet*).

The project, collaboratively written, went through two phases of evaluation: a peer evaluation with the possibility of improving the work basing on the received feedback, and a trainers' evaluation (the evaluator was the trainer who followed the group from the inside). An evaluation grid was constructed by the trainers to encompass all the phases of the project design, developed in the MOOC week after week. This grid was structured around the following four criteria: 1) Accuracy of the definition and description of the project; 2) Relevance of the mobilised digital tools and resources with respect to the educational goals of the designed mathematical task; 3) Relevance of the analysis of the students' expected mathematical activity; 4) Relevance of the analysis of the teacher's role.

For each criterion, some guiding questions were proposed with a double objective: to foster the production of justified feedback and to deepen the reflection carried out in the previous weeks of the MOOC. The grid finally asked for a brief global feedback on the project and some suggestions to improve the work. Each trainee was invited to use the grid individually to evaluate the project of another group, by answering each guiding question with an evaluation: very good, satisfactory, fragile or insufficient, accompanied by a justification. The community managers gradually collected feedback and comments in a table and shared it in a specific space on Viaéduc, called "Project evaluation", so that all the trainees could access them.

After the MOOC, a questionnaire was sent to all the enrolled participants to get feedback on such an experience of distance training, with a particular focus on the collaborative project and collaborative tools of Viaéduc. As trainer-designers, we are taking this feedback into account for the third season of the MOOC.

DISCUSSION AND CONCLUSIONS

In this paper we have introduced and compared two different MOOCs for training in-service secondary schools mathematics teachers, one in France and one in Italy. The courses were designed according to a different structure in the two countries, because of the different institutional school backgrounds and traditions, but they had two common goals: (i) to foster the professional development of teachers through a suitable mediation of technology; (ii) to trigger as much as possible the engagement of participants in order that they could develop from a non-community towards one or more communities of practice (and possibly of enquire). These two goals are related to the two research questions listed above and put forward some challenging methodological issues for the research teams: the design principles and the assessment of teachers' engagement.

For the design both teams had to hypothesize a "common" zone of proximal development (Vygotsky, 1978) of participating teachers with respect to their pedagogical and mathematical knowledge mediated by technology – what Mishra and Koehler (2006) call TPACK – so that the proposed activities could be interesting for the majority of trainees and introduced them to situations they were able to approach and elaborate. The MOOCs were also a training opportunity for sharing the results and the reflections about research projects with the community of teachers. But the major related problem was to transpose such an information into the MOOC environment, namely we had to transpose the usual methodology of training courses into images, words, videos, and nothing else: we had so to choose friendly open source tools that could be easily available and that could be easily used in the trainees' activities in their own classrooms. We had to support the developing community not imposing the team's presence but being vigilant and ready to intervene promptly in case some help is required. Implementing some webinars in the MOOC, where the "expert" could communicate through a video-chat with the trainees, as well as proposing a trainer per group as a personal tutor, had the purpose (and effect) of making trainees feel accompanied and become faithful followers. As said above, the positive effects of such a complex design were tangible: in fact, while the literature says that the percentage of people who complete a MOOC is about 5% (Bayne & Ross, 2013), in the French MOOC it was 12%; in the Italian MOOC Geometria it was 36%; and in the successive Italian MOOC Numeri it was 43%.

To concretely check the possible development of communities of practice, some more creativity from the designers' teams was required: it is not an easy task to extract data from the MOOC environment, where the researchers must base only on the stored traces and messages that the participants leave on the MOOC devices, on the tasks they upload and on their answers to the questionnaires. Of course this second issue is strictly linked to the previous one: having data easy to access strongly depend on the type of activities required to the participants and to their willingness to do them. Hence a first filter consists in checking if the trainee has accomplished all the required tasks. For this, a good strategy could be using a gamification context within the training: e.g., in Italian case, each week a badge was automatically released to those who did everything: the sequence of the got badges certificated the level of participation to the course. A second important evaluation tool is the elaboration of a final project, where the trainee could show how she was able to apply what had been presented in the course. This second evaluation was based in both MOOCs on a peer review, complemented in France with a trainers' evaluation of the project necessary for delivering the university certificate. We took care of this aspect, and we recommend to do it as MOOC designers, because obtaining such a certificate of completion by universities can be an important stimulus for teachers to engage in distance training. The (relatively) good percentage of people who ended the MOOCs shows that this goal was positively achieved in both cases.

Of course not everything was rosy in our experience. In both MOOCs we realized that a project-based methodology can create a gap between the timeline of the MOOC (videos, quizzes, activities) and the timeline of the project, which can destabilize the trainee in some cases. For these reasons, in the following seasons of the MOOCs, the time factor has been taken into greater account, leading also to modify some aspects of the design.

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