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Supporting Teachers in the Design and Implementation of Group Formation Policies in MOOCs: A Case Study

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Abstract: Collaborative learning strategies, which can promote student learning and achievement, have rarely been incorporated into pedagogies of MOOCs. Such strategies, when implemented properly, can boost the quality of MOOC pedagogy. Nonetheless, the use of collaborative groups in MOOCs is scarce due to several yet critical contextual factors (e.g., massiveness, and variable levels of engagement) that hamper the group formation process. Therefore, there is a need for supporting MOOC teachers in the design and implementation of group formation policies when implementing collaborative strategies. This paper presents a study where two instruments were used to explore solutions to this need: a guide to support teachers during the planning of the group formation, and a technological tool to help them implement the collaborative groups designed and to monitor them. According to the results of the study, the design guide made the teachers aware of the contextual factors to consider when forming the collaborative groups, and allowed teachers inform some configuration parameters of the activity (e.g., duration and assessment type) and the group formation (e.g., criteria and parameters needed to build the groups). The technological tool was successfully incorporated into the MOOC platform. Lessons learned from the findings of the study are shared and their potential to inform the design guide is discussed.

Keywords: MOOCs, Group Learning Activities, Collaborative Learning, Teams
Categories: K.3.1, K.3.2, L.3.6, L.6.2

1 Introduction

Collaborative Learning (CL) has been a popular strategy employed in various educational contexts (face-to-face or online) as it offers many learning benefits [Kreijns et al., 2003]. CL helps improve learning since it provides social and cognitive competences that could not be acquired through individual learning [Laal and Ghodsi, 2011]. With the emergence of MOOCs (Massive Open Online Courses), new opportunities have emerged to harness the potentials of collaborative learning in these new learning settings. Such massive contexts bring together many students with different characteristics, skills, and goals and offer them the opportunity to work together and take advantage of the diversity. However, at the moment, it is rare that MOOC practitioners incorporate collaborative learning strategies in their pedagogies. Currently, most MOOCs follow an instructivist pedagogical approach, in which they provide lecture content (text or video) organized into (usually weekly) modules and assess learners' performance by means of automatically graded quizzes [Daniel, 2012]. This dominant pedagogical approach in MOOCs has been widely criticized and has raised several concerns regarding its instructional effectiveness and its possible impact on students' disengagement and high dropout rates [Margaryan et al., 2015].

Many researchers have underlined the need for enriching MOOCs with active pedagogies [Ferguson and Sharples, 2014] [Manathunga and Hernández-Leo, 2015] such as CL. In fact, several studies have explored the use of CL in these massive courses and reported promising results regarding its effects on student learning and performance [Ferguson et al., 2015] [Alario-Hoyos et al., 2016] [Blom et al., 2013]. One reason for the rare use of collaborative learning in MOOCs is that massive scale and open learning introduce difficulties for instructors in the design and enactment of Group Learning Activities (GLA) [Dillenbourg et al., 2014]. The orchestration of GLA is a demanding and time-consuming task that involves many decisions, such as those related with the formation of groups and the monitoring of their performance. When configuring the groups for a GLA, MOOC instructors need to mobilize a learner population that is in greater numbers and diversity in comparison to those in other learning settings. Among MOOC participants, there are distinct subpopulations of learners with varying levels and types of engagement [Kizilcec et al., 2013], which may negatively affect the performance of the formed teams and make their orchestration harder. Similarly, in MOOCs there are latecomers and dropouts [Ferguson and Clow, 2015]. Such learners may hamper the group formation process when designing and enacting GLA. As a result, the uses of CL in MOOC contexts are still mostly limited to peer reviews [Er et al., 2017], forum interactions [Brinton et al, 2013] or external social tools [Alario-Hoyos et al., 2013], lacking the implementation of small-group learning activities.

Given the need for support in the design and enactment of GLA in MOOC contexts, our research work aims at exploring *how teachers can be supported in the design and implementation of Group Formation Policies to carry out GLA in MOOCs*.

In this paper, we tackled the problem through an exploratory study in a real MOOC where two supporting instruments were used. The conclusions of this experience could be used to facilitate the orchestration of collaborative groups and

therefore the implementation of GLA in MOOC contexts. In the study, we offer two stages of teacher support that focus on addressing issues rooted in MOOC contexts (e.g., latecomers, dropouts and varying engagement levels). The first stage of support takes place in the design phase of the course, and it involves the use of a design guide. This guide aims to enable the instructor to consider MOOC features and GLA properties that could hamper group management, and therefore to configure beforehand the GLA and the grouping policies to avoid or mitigate the issues rooted in the MOOC context. The second stage of support takes place during the enactment phase by enabling the instructor to orchestrate the group management (i.e., formation and monitoring) using a software tool. This tool provides capabilities to select and apply criteria in order to create the collaborative groups of students and to monitor their activity.

The rest of the paper is organized as follows. Section 2 reviews works related with supporting teachers in the design and implementation of collaborative strategies focusing concretely on group formation policies, in MOOC contexts. Section 3 presents the instruments used in this study, intended to support teachers in the design and implementation of Group Formation Policies in MOOCs: MyGang Design Guide (MyGang_DG) and MyGang Tool (MyGang_T). Section 4 describes the exploratory study, core of this paper, that was carried out in a MOOC developed in the Canvas Network Platform. In section 5, we present the results and findings of the study, and discuss the lessons learnt. Finally, section 6 shows our conclusions and future work.

2 Related Work

In the last decades, many systems, tools and frameworks have been developed to support the design and deployment of collaborative learning activities in various learning environments. For example, [Hernández-Leo et al., 2006] introduced a tool, called Collage, to facilitate the co-design of collaborative learning activities with the teachers. [Villasclaras-Fernández et al., 2013] present another tool called Web-Collage, which helps teachers in the task of designing CSCL scripts with assessments. Moreover, [Prieto et al., 2013] proposes a system to enable teachers to deploy collaborative learning designs across distributed learning environments. Furthermore, [Hernández-Leo et al., 2014] proposed a comprehensive system (called ILDE) to help teachers complete various tasks involved in the learning design lifecycle, allowing the integration of external tools. ILDE allowed teachers to design various types of collaborative learning strategies. Also, [De Hei et al., 2016] developed a comprehensive framework to guide teachers in higher education in designing, implementing, and evaluating group learning activities. Such research efforts have supported teachers in various ways in the design and enactment of collaborative learning strategies; however, they mainly target formal and small scale learning settings, thus having limited implications in massive learning contexts.

There have been some research studies to support the design and enactment of collaborative learning strategies in MOOCs. With respect to *design*, among the few studies aiming to support the design process of MOOCs, [Conole, 2013] identified twelve criteria or dimensions that can be used not only to classify MOOCs, but also to plan their design. One of these dimensions was related to the extent to which collaboration is included in the course. In her follow-up work, [Conole, 2015]

proposed a method to design effective MOOCs considering these twelve dimensions. Other studies have proposed a conceptual framework to help educators address a variety of issues when designing a MOOC [Alario-Hoyos et al., 2013]. [Grünewald, 2013] focused on analyzing the need for designing MOOCs to support different learning styles, presenting arguments for a future development of models that bridge the gap between xMOOC and cMOOC models. In her study, the author highlights the need for a culture of participation and outlines some guidelines to support this culture. [Ortega-Arranz et al., 2017] tackled the problem of upgrading a low scale course to obtain a collaborative and gamified MOOC through a participatory design carried out by teachers and researchers. However, none of these works has specifically focused on supporting the instructor in the design of group formation policies for GLA in open and massive courses.

On the other hand, regarding the *implementation*, the development of technological tools to support the enactment of collaborative groups in MOOCs has been scarce. [Zheng et al., 2015] developed an algorithm to automatically form collaborative learning groups in order to explore the effects of small learning groups on dropouts. In her thesis, [Wen, 2016] used natural language processing techniques to support the collaboration of suitable groups via the identification of students that shown transactive reasoning in forums prior to the course. In their study, [Wichmann et al., 2016] created homogeneous and heterogeneous groups of students based on their engagement in the course and compared the performance of these groups. Finally, [Sanz-Martínez et al., 2017] developed a tool to automatically create small groups of students using teachers' criteria. In any case, all these studies have been experimental and the tools developed have not reached the community of teachers that could be interested in including GLA in MOOCs. Therefore, teachers only have the currently limited support offered by the MOOC platforms to manage collaborative strategies.

Moreover, we deem that to support teachers in the creation and orchestration of groups to carry out GLA in MOOCs, it would be useful and recommendable to have a holistic view of all the factors that can affect group management. The MOOC context issues and the GLA design and configuration in such context, strongly affect the management of the groups, and therefore these factors should be taken into account.

3 Instruments Used in the Study

In our research process, we iteratively developed a framework, called MyGang (Mooc analYtics for Group Assignment and moNitorinG), through which we aim to organize the available information regarding the issue of managing collaborative groups in MOOCs. It has been developed based on literature review and experts' opinions, and it has been enriched and evaluated through iterative interventions. Currently the framework is composed of five artifacts:

-*Context* (MyGang_C): Extrinsic characteristics that affect the management of groups were identified per each intrinsic feature of MOOCs.

-*Grouping Factors* (MyGang_GF): Both pedagogical and technological factors to consider in the management of collaborative groups in MOOCs were derived.

-*Architecture* (MyGang_A): A system architecture of the envisioned supporting tool to manage groups in MOOCs was designed.

-*Design Guide* (MyGang_DG): MyGang_C and MyGang_GF (partly) were instrumentalized as a guide to support teachers.

-*Tool* (MyGang_T): MyGang_A was instrumentalized to support the implementation of group formation policies in MOOC contexts.

The last two artifacts, MyGang_DG and MyGang_T, were the ones tested in this study. This section provides an overview of the other three, on which the tested artifacts build their functionalities.

MyGang_C, shown in Figure 1, presents, in a structured fashion, the intrinsic features (Massive, Open, Online and Course) of MOOC contexts, and their derived extrinsic properties. This information is used in the Design Guide (MyGang_DG), to make teachers reflect on the impact of the context on the management of groups.

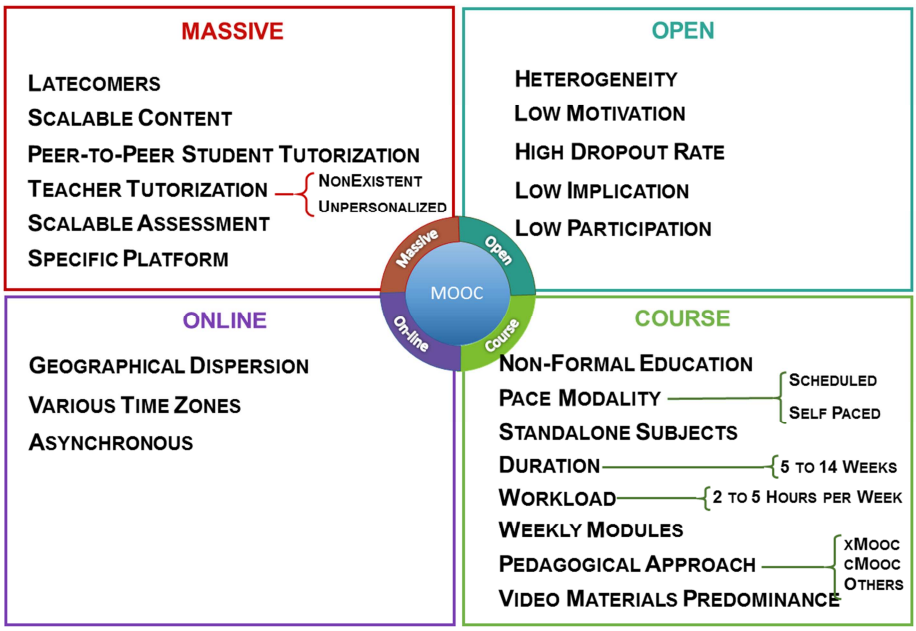

Figure 1: Intrinsic and extrinsic features of the MOOC context

In Figure 2, MyGang_GF, the Grouping Factors artifact of the framework is shown. It depicts a hierarchical classification of the influential factors to manage collaborative groups in MOOCs. The possible factors are divided into two main subsets related to pedagogy and technology. The pedagogical factors are also split into three categories (i.e., Learning Design, Dynamic Data, and Static Data). The list of factors shown in the figure is not intended to be exhaustive, but rather to illustrate some examples of the aspects that can be considered in each category. Among the aforementioned categories, *Static Data* refers to the information that is not updated during the course enactment (e.g., demographics, preferences, etc.) collected from students, usually through surveys, at the beginning of the course. On the other hand, we consider as *Dynamic Data* the information monitored and updated while the

course is running, that is mostly the trace data that emerge through students' learning activities and interactions. The *Learning Design* factors are aspects related to the learning design decisions that affect the group composition.

The pedagogical categories of MyGang_GF were used to develop three sections of the Design Guide (MyGang_DG) in order to make teachers aware of the GLA properties that they should consider in their design, and the criteria that they can apply to configure the groups needed to carry out the GLA in a MOOC.

According to these specifications, the *Design Guide* (MyGang_DG) consists of four sections related to the MOOC context features (see Figure 1) and the three dimensions of the pedagogical factors (see Figure 2). In its current state, the guide may be used in a co-design process (as shown in Figure 4) in the form of interviews with the teachers in order to discuss every item included in it. The researcher should give advice about the possible advantages and drawbacks of every decision taken by the teachers based on prior experiences, literature and experts' opinions. The first section of the guide is aimed at making teachers aware of the context features that affect group formation. It includes questions to reflect and select concrete characteristics of the envisioned MOOC using the researcher recommendations. The rest of the sections of the guide should be filled out once for each GLA to be designed. The second section is focused on configuring the learning design characteristics of the GLA that have impact on the group formation, e.g., the application of a Collaborative Learning Flow Pattern (CLFP). Sections three and four are intended to help the teachers elicit the static and dynamic data factors that can be considered to configure the groups by using them as grouping criteria. In these last sections, teachers assess the importance and impact of using each factor in the envisioned GLA and choose what factors they would like to use in the group management of each collaborative activity.

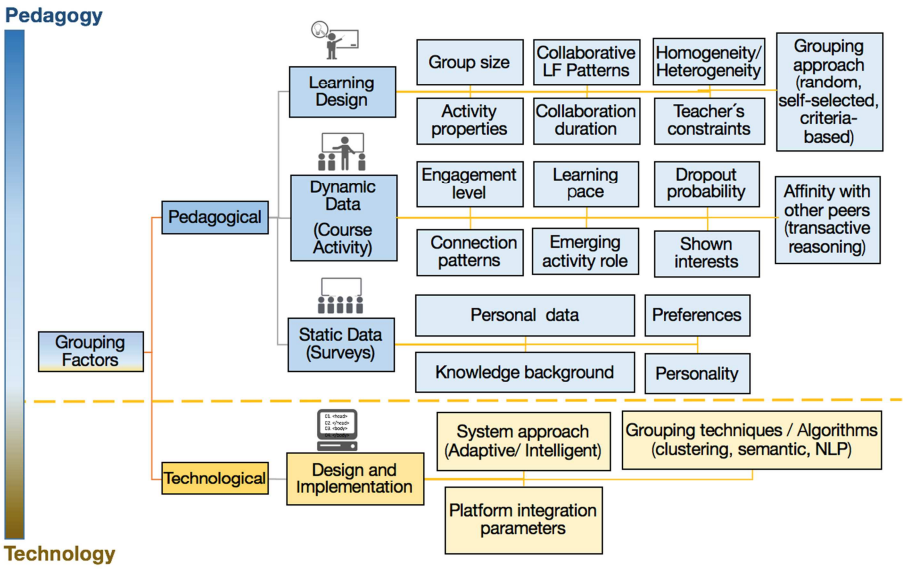

Figure 2: Classification of influential factors related to group management in MOOC

The third artifact of the framework is the architecture, a high-level design of the envisioned group-management supporting tools' structure. It uses the pedagogical Grouping Factors (i.e., Learning Design, Dynamic Data and Static Data) as data inputs for the system. The system is composed of several modules that include adapters to import/export data from/to the MOOC platform: (a) a Dynamics Processing Module, to gauge and estimate dynamic factors (such as the engagement, the emerging role or the dropout probability) using the raw dynamic data collected from the platform; and (b) a Grouping Module, to configure the group structures based on the collected data and on the specifications given by the teachers.

The Tool (MyGang_T) developed for the study included an early version of an interface module, which receives the input (e.g., group size, grouping criteria, etc.) through a configuration file and produces on-demand reports about the groups' performance. The functionalities of the rest of modules were developed in order to satisfy the concrete specifications of this study. The adapters were programmed to meet the Canvas Network platform requirements and the grouping module to implement the group configuration specifications provided by teachers. The specifications to configure the groups included: (a) three levels of priority where criteria should be applied, (b) several criteria in each level and (c) the use of both homogeneity and heterogeneity with respect to the criteria that have been chosen.

4 Description of the Study

The present study is part of wider research process conducted through a Design Based Research Methodology (DBR) [McKenney and Reeves, 2012]. In this paper, we report the second study of the second iteration of the process, in which we continued exploring how MyGang_DG and MyGang_T supported teachers in the design and implementation of group formation policies in MOOCs. The aim of the study was not to provide generalizable results, but to gain deeper understanding of the usage of the tools to inform the next iteration of the research process, and contribute to the definition of the design principles that will eventually help to answer our research question.

In this section, we describe in more detail the research question of the study, as well as its context, the data sources used and finally, the GLA description and the group configuration produced as a consequence of the design support offered.

4.1 Research Question

The main goal of our research project is to support teachers in the design and implementation of Group Formation Policies to carry out GLA. To that aim, we carried out a study in a real MOOC to explore the problem and to test the usefulness of two instruments, a design guide and a technological tool, intended to support teachers in two stages (design and implementation). Therefore, we posed the following general research question: *How can teachers be supported in the design and implementation of Group Formation Policies in MOOCs?*

To answer this research question, we performed an anticipatory data reduction process [Miles and Huberman, 1994], identified two main issues that should be explored in this study through different topics, and defined the questions to illuminate

them, as shown in Figure 3. The first issue (i.e., I1) was related to MyGang Design Guide and the way in which it supports the design of group formation policies in MOOCs, while the second issue (i.e., I2) was related to MyGang Tool and its capabilities to support the formation and monitoring of groups needed to carry out GLA in MOOCs.

The topics corresponding to I1 aimed at exploring the three levels of aspects to be considered in the design of group formation policies (i.e., context issues, GLA design and group configuration), while the topics of I2 aimed at testing the feasibility of a software tool in MOOCs. The *suitability* of the GLA was assessed in terms of complexity and duration, and also participation, requirements accomplishment and completion by the students. On the other hand, the adequacy of the criteria selected to create the groups were related to the achievement of as many active participants in a group as possible and the degree of satisfaction of the students with their teammates.

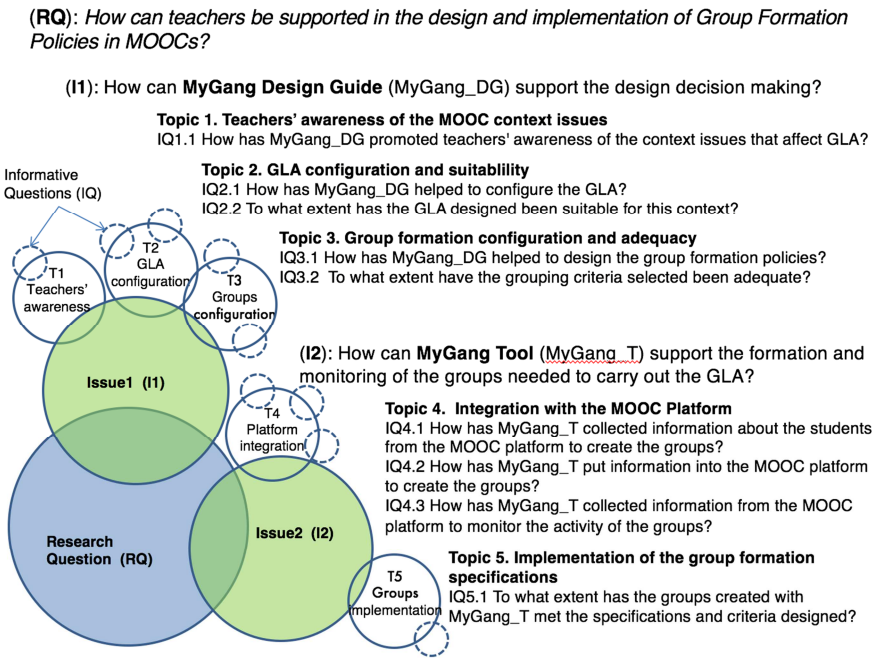

Figure 3: Anticipatory data reduction diagram showing research question (RQ), issues (I), topics (T) and informative questions (IQ)

4.2 Context

The study was carried out in a five-week MOOC named "Innovative Collaborative Learning with ICT" offered by the University of Valladolid, Spain. The course was delivered both in English and Spanish. The course targeted innovative pre-service and in-service teachers interested in incorporating collaboration with technology into their own teaching practices. The two instructors of the course were very experienced in CL and ICT, but this was the first MOOC in which they participated. We formed a

co-design team composed of these instructors and the researcher in order to design a GLA to be deployed on the second week of the course.

The course was deployed in the Canvas Network platform between June the 12th till July the 24th, 2017, i.e., a total of six weeks: five weeks (one for each of five modules) plus an additional week to allow students to complete the peer review of the final project and fill out the final satisfaction survey. The enrolment was closed at the end of the first week to allow us to configure properly the groups for the collaborative assignment of the second week. A free certificate was given to the students who completed the mandatory assignments (one per week) in addition to the two surveys. The participation in the course and the completion rates were low compared with other courses of short duration, that could be attributed to the period in which the course was deployed (June and July) when the target students (i.e., in-service teachers) had a high workload. The patterns of student engagement in the course were proportionally similar to those reported in literature.

The total number of enrolments was 759, but only 671 of them remained enrolled at the end of the course. 174 students filled out the initial mandatory survey (needed to configure the groups) and 52 filled out the final satisfaction survey, however only 29 of them (3.8% of the enrolled) achieved the requisites to obtain the certificate.

4.3 Data Sources

We used a mixed methods approach, with a predominance of qualitative data, in order to better capture the effects of the instruments examined in the study. Mixed methods allowed us to complement and triangulate results [Greene et al., 1989] by using several data sources to collect information to answer the informative questions. This approach is a consequence of our underpinning pragmatic worldview, centered in the problem and oriented to real world practice [Creswell, 2014]. Accordingly, we gathered data from seven sources and three informants shown in Table 1.

Figure 4 shows the timeline of the data collection from the various sources. The first event was the submission of MyGuide_DG to the teachers to make them aware of its contents and the questions and decisions they were going to take. Then, an interview (i.e., pre-codesign session) with each teacher was scheduled in order to comment, discuss and give them advice about every item of the guide.

Source/ Informant/[Code]	**Description**
Interviews/ Teachers/[X_Int]	Interviews carried out after the use of MyGang _DG to: [*Dsng_Int*]- Co-design the GLA with the instructors and select the criteria for the group formation. [*Feed_Int*]- Collect instructors' feedback about their satisfaction with the produced design and its enactment.
Learning Design/ Teachers/[LD]	The learning design of the course provides information about how MyGang_DG helped configure the GLA and the group formation policy.
Questionnaire/ Teachers/[Quest_X]	Questionnaire to assess the utility of MyGang_DG. [*Quest_T<n>*]- Filled out by [*Teacher<n>*]
Observation/ Researcher/[X_Obs]	Researcher observations to determine: [*Gen_Obs*]- Observations on the achievement of objectives. [*Crit_Obs*]- To what extent groups created with MyGang_T met the criteria and specifications designed by the teachers. [*Intg_Obs*]- How MyGang_T was integrated within the MOOC Platform.
Surveys/Students/ [X_Sur]	Mandatory course surveys, composed of open-ended and closed questions in a 7-point Likert scale. [*Welc_Sur*]- Used at the beginning of the course to get demographic data and preferences of the students that will be used as grouping criteria. [*Satis_Sur*]- Used at the end of the course to measure students' satisfaction with the GLA.
Platform Analytics/ Students/[Platf_X]	Canvas LMS REST API used to collect data about: [*Platf_engag*]- #page_views, #submitted assignments and #posted messages in forums. These data were used to compute the student engagement level (to be used as grouping criteria). [*Platf_Monit*]- Students participation in groups to identify: active teams, active members in each team, etc. used to evaluate the suitability of the GLA designed and the groups formed in second week.
Communications/ Students/[Com]	Emails and personal messages sent in the MOOC platform from the students to teachers during the GLA assignment.

Table 1: Data sources and informants used (codes indicated within brackets) to create the groups and to answer the informative questions

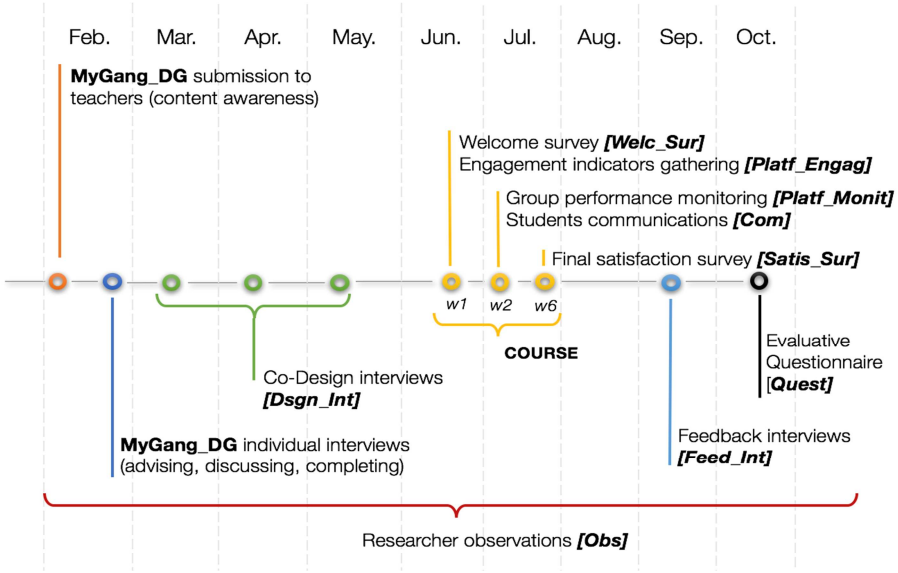

Figure 4: Data collection timeline

4.4 GLA designed and grouping formation policy selected

The Group Learning Activity (GLA) was composed of two parts. In the first part, students were required to work individually to review and test five technological tools, one from each different category (a list of categories and tools were provided by the instructors of the course). After testing the selected tools, the student must decide on the one that is the most suitable, in their opinion, to be used for enriching the learning scenario proposed by the teachers in the first week of the course. Then, students were asked to reflect on how this tool could be used to enrich this scenario.
In the second part of the activity, the students were required to work in groups of five and share their work from the first part with group members and justify their choice in a shared Etherpad document. Then, they were asked to argue and discuss in the group forum to reach a consensus on the tool to be chosen and present it as a group proposal. All groups were also asked to choose a spokesperson, who would be in charge of submitting the selected group proposal.

The criteria selected by the teachers to create the groups for the activity included three levels of priorities and used both static and dynamic factors (see Figure 2) as criteria. These criteria were meant to be applied to form homogeneous groups in some levels and heterogeneous ones in others.
Next, we summarize the criteria applied to form the groups, ordered in three levels of priority:

-*First priority level of criteria*. In this level two sets of static student data from the welcome survey were used: the *language* ("Spanish" or "English") and the *preferred days to work in the course* ("from Monday to Friday" or "Saturday and Sunday").

These two criteria were applied to form homogeneous groups, resulting in four cohorts. Then within these cohorts, the rest of the grouping criteria were applied. In addition, all students that had not filled out the welcome survey were placed in a separate big group labelled as *NoQuestionnaire,* where no criteria were applied.

-*Second priority level of criteria*. The teachers chose to use a dynamic factor and student engagement levels to form heterogeneous groups at this priority level. It should be noted that separate clustering processes were applied for each of the four cohorts, which were derived from the application of the first priority level of criteria. To measure student engagement, three elements were taken into account: engagement with course contents, engagement with course discussions, and engagement with course assessments, in line with the criteria proposed by other authors [Ferguson and Clow, 2015]. We used the following indicators collected from the platform analytics as the measures for each type of engagement, respectively: (i) number of page_views, (ii) number of posted messages in forums, and (iii) number of submitted assignments. These indicators were standardized and used to categorize the students from each cohort into as many levels as the number of required members of a team (five in our case). Then, in order to form the heterogeneous team, students belonging to each engagement level were assigned to every group. To choose the concrete student of each level to be included in a group, we needed to consider the criteria of the third level of priority.

-*Third priority level of criteria*. In this level five static student data variables gathered from the welcome survey were used, i.e., ICT_experience, ICT_attitude, CL_experience, CL_attitude and knowledge_domain. All these variables were in the same scale, so no normalization was needed with them. They were applied to form heterogeneous groups. To do so, we applied Principal Component Analysis (PCA), a statistical procedure used to reduce the dimensionality of a dataset. This way, we obtained a single resulting variable that could be integrated with the criteria of the second level, which was intended also for group heterogeneity. We achieved this integration by choosing the students from each level of engagement in a way that maximizes the Euclidean distance with the resulting variable of the PCA.

5 Results and Findings

In this section, we firstly present the responses to the informative question posed in subsection 4.1 regarding the use of MyGang_DG and MyGang_T. Then, we summarize the main findings of the study, and we finish by exposing some lessons learnt from the pitfalls of this experience.

-[IQ1.1]- How has MyGang_DG promoted teachers' awareness of the context issues that affect GLA?

[Teacher1], very experienced in CL, highlighted the utility of section 4 of MyGang DG. This section, related to Dynamic Factors, helped him to make decisions regarding the design of the GLA and the grouping criteria. ("*Perhaps section 4 has made me think about the things. Mainly, having to think about which "MOOC-like" criteria I had to keep in mind. This can help someone experienced in CL but not in MOOCs.*" [Quest_T1]). Moreover, [Teacher1] considered that the guide could help teachers who are less experienced in CL than him. ("*Probably for someone less*

experienced in CL, this would be much more useful." [Quest_T1]. In his own opinion, as [Teacher1] already knew the possible issues emerging from MOOC contexts, the guide did not help him much beyond reminding him of these issues. However, the observations made by the researcher [Gen_Obs] showed that [Teacher1] underestimated the complexity introduced by the MOOC context, and consequently few students could follow precisely the instructions of the GLA, and complete accordingly these activities [Platf_Monit] and [Gen_Obs]. Additionally, the guide helped him to focus on the aspects needed to classify students to make successful groups in this context. ("Maybe it helped me to think what focus on to "classify" students in order to group them." [Quest_T1]).

[Teacher2], expressed that the guide helped her to better understand the issues affecting GLA because it enabled her to reflect on various characteristics of MOOCs which she had never taken into account in other learning contexts. ("*It helped me because it made me reflect on questions I do not have in mind in small scale contexts, for instance, on when to close the enrolment in order to allocate all the students to groups. There are many aspects that must be considered from the very beginning of the conception of the MOOC*" [Quest_T2]). She also mentioned that her point of view changed regarding the usefulness and effectiveness of homogeneity applied in certain criteria to form student groups. Previously, she had followed the dominant learning sciences standing, i.e., that heterogeneity in groups provides better results in terms of overall learning, social skills, equity, etc. But after the use of the guide, her opinion was that in MOOCs some homogeneity could be needed to achieve groups of students that may be suitable to work together. ("*There were some things very clear to me in small scale context such as the promotion of groups as much heterogeneous as possible in order to [...] but now I think that in MOOC context it is good to have some homogeneity regarding certain characteristics*". [Quest_T2]). The guide made her also consider several aspects about the GLA such as the way to assess and tutor it. ("*There were some aspects that I have never considered before, such as that the way of assessing and tutoring must be adapted to these contexts*". [Quest_T2]).

-[IQ2.1]- How has MyGang _DG helped to configure the GLA?

The teachers were able to decide on several aspects of the GLA description through their individual interviews with the guide and the co-design interviews [Dsgn_Int] that enabled them to: (i) reflect on the possibilities of applying a Collaborative Learning Flow Pattern, such as jigsaw or pyramid. ("*The researcher presents a draft design of a jigsaw, but teachers reject it selecting to design the first level of a pyramid*." [Dsgn_Int]"); (ii) choose activity properties such as the production of an artifact and the need for a preliminary discussion of individual ideas in order to reach an agreement; (iii) select the activity duration (i.e., one week). ("*The teachers reflect on selecting three days of duration but the researcher recommendations make them reflect about the lack of availability of some students during working days*" [Dsgn_Int]); (iv) decide on how to assess the activity, evaluating it as "Passed" if they submit both the individual and the group proposals and (v) decide on how to tutorize the activity and solve the students' doubts.

-[IQ2.2]- To what extent has the GLA designed been suitable for this context?

The suitability was analyzed in terms of adequacy to the context, mainly regarding its complexity and duration. We also analyzed some success parameters as

a measure of its feasibility regarding participation, requirements accomplishment and completion by the students.

The number of submissions for the mandatory assignments in each week was: w1: 70, *w2: 64*, w3: 40, w4: 35 and w5: 32. Therefore, the GLA of the second week was the second assignment of the course in terms of participation and completion. This indicates a regular rate considering the progressive decrease of participation in the MOOC. However, many students did not accomplish the steps stated in the assignment specification (e.g., writing in the forum that was specified in the assignment description, justifying their choice, selecting the spokesperson, etc.). To explain this fact, we collected the teachers' opinions through feedback interviews [Feed_Int] and revised the students' communications. This information, together with the researcher observations, gave us some possible reasons for the poor attainment of the activity, and therefore some suitability issues: (i) several students did not carefully read the GLA description, since it was too long; (ii) the GLA complexity was rather high, since it involved several ICT tools and (iii) the time needed to carry out the GLA was longer than expected.

-[IQ3.1]- How did MyGang_DG help instructors design the group formation policies?

The guide supported teachers in configuring multiple aspects of group formation: (i) the use of criteria for group formation, i.e., groups were neither formed randomly, nor through self-selection by students; (ii) the group size, five students per group. The possibility of oversizing the group to seven, in order to have some redundancy to prevent a low rate of participation was discussed in the [Dsgn_Int], but finally not selected; (iii) the static data that should be included in the welcome survey, to be used as grouping criteria, i.e., language, preferred days to work on the course, experience in CL, attitude towards CL, experience in ICT, attitude towards ICT, and the domain of knowledge in which they had teaching experience; (iv) the dynamic data, that should be collected from the platform analytics, to be used as grouping criteria, i.e., the engagement indicators; (v) the levels of priority for each set of criteria and (vi) the use of homogeneity or heterogeneity in each level.

-[IQ3.2]- To what extent have the grouping criteria selected been adequate?

The adequacy of the criteria was analyzed in terms of the achievement of as many active participants in a group as possible and the degree of satisfaction of the students with their teammates. The analysis of the group activity and performance gave us the following information:

There were 35 groups created by the tool according to the group formation criteria configured by the instructors, but it was needed to create two more groups (one for each language) to reallocate some students who expressed their dissatisfaction with the group they belonged to, because of the absence of their teammates. Therefore, the final number of collaborative groups was 37. One more group was created to allocate the students who did not fill out the survey, since some of the criteria used to form the groups employed data from this survey.

There were 28 active groups (75.7%), that is, they had activity in their forums (i.e., posted messages) and submitted the assignment. In the remaining 9 groups, none of the members performed any action. Within the active groups, 5 of them had 3 active members who participated in the activity (2 of these groups were created afterwards to reallocate dissatisfied students); 14 groups had 2 active members and 9

groups had only 1 active member. In their communications to teachers [Com] and the satisfaction survey [Satis_Sur], many students expressed their dissatisfaction with their group work experiences. Their main complaint was about the presence of inactive students in their group. This fact confirmed our previous finding and recommendation to teachers about the advantage of applying criteria to achieve as many active students in a group as possible [Sanz-Martínez et al., 2017]. Although all students that constituted the dataset of the group formation had filled out the welcoming survey, and therefore they had shown at least a minimum level of participation in the course, the heterogeneous distribution of students regarding their engagement level led to groups with many inactive students.

-[IQ4.1]- How has MyGang_T collected information about the students from the MOOC platform to create the groups?

The data from the welcome survey were downloaded from the Canvas Platform in a .CVS file, which fed the tool prototype, that processed and stored them in order to create the feature vector used for group formation.

The tool used also the Canvas LMS REST API to obtain information about the students' activity during the course. The GET functions used were:

(i) GET course-level student summary data. - Used to obtain the number of pages viewed by each student, stored in the variable [num_page_view] of the feature vector.

(ii) GET user-in-a-course participation data. - Used to identify the concrete pages visited by each student in order to extract their participation in the forums, stored in the variable [num_post_mess] of the feature vector. This function was also used to obtain the number of assignments submitted by each student, stored in the variable [num_subm_assi] of the feature vector.

With these variables the tool gauged, in the Dynamics Processing module, the engagement level of each student, categorizing it into five levels.

-[IQ4.2]- How has MyGang_T put information in the MOOC Platform to create the groups?

To create the groups the tool prototype used the following Canvas LMS REST API functions:

(i) POST Create a group. - Used to create a group within an existing category.

(ii) PUT Edit a group. - Used to modify a group, allows to assign members to the group by specifying in one of its parameters an array containing the member IDs.

-[IQ4.3]- How has MyGang_T collected information from the MOOC platform to monitor the activity of the groups?

To monitor the groups' activity, the tool prototype used the following Canvas LMS REST API functions:

(i) GET List discussion topic. - Used to obtain the group discussion (i.e., group forums.

(ii) GET a single topic. - Used to obtain every topic of the forum and identify its owner.

With this information the tool, by means of a recursive function, determined the participants of each group, the number of messages sent by each participant and, the number of active participants of the group.

(iii) GET List groups in group category. – Used to obtain the list of groups.

-[IQ5.1]- To what extent has the groups created with MyGang_TP met the specifications and criteria designed?

The first level of grouping criteria implemented in MyGang_TP aimed to create homogenous subsets of students according to their preferred language of instruction and the preferred days to study the course. According to results, the tool was able to create fully homogeneous subsets of students as desired by the instructor.

The criteria of the second level of priority must be applied to form heterogeneous groups regarding students' engagement levels. To meet this criterion precisely it would be necessary to have exactly the same number of students from each engagement level. However, there were more students with low levels of engagement than those with high levels of engagement. As a result, there were some groups which contained higher numbers of low engagement students, thus resulting in heterogeneity lower than intended.

The criteria of the third level of priority, by definition, should have a lower impact than the previous levels. To apply the third level criteria, we used a PCA process in order to reduce the five variables selected by the teachers into one resulting variable. This allowed us to combine this variable with the criteria of the previous level (i.e., by maximizing the Euclidean distance regarding this variable when selecting the students of each level). Therefore, the impact of these third level criteria had a slight impact on some groups.

Besides the main *findings* shown in Table 2, we present below some *lessons learnt* from the pitfalls of this experience that can help us to improve *MyGang _DG* and *MyGang_T* for the next iteration:

-It would be desirable to offer clear and complete guidelines to students to accomplish the GLA, however very long descriptions can tire and bore students. Therefore, alternative ways to describe the activity, such as graphics, schemas or videos, could be implemented.

-It would be convenient to schedule the GLA on the second half of the course in order to have a stable dataset regarding students' engagement.

-It would be recommendable to achieve groups with as many students active as possible, thus avoiding inactive students, which frustrate their teammates.

-When the observed participation of the students in the course is quite low, application of complex pedagogical criteria to group them has minor impact. Instead, it would be better to connect the active students together.

-Regarding the application of several levels of criteria, it is convenient to prioritize those related to connecting the active students and then to apply the rest of criteria with lower priority.

-Instead of taking the final decision on the grouping criteria during the design phase, software tools can serve to analyze the student dataset during the course enactment in order to recommend grouping criteria adapted to the concrete population.

-Even if the teachers were able to identify issues related to MOOCs, it was not sufficient to obtain a suitable collaborative design. We should find out, in future works, how to make teachers aware of the problems of CL in MOOCs.

Topic	**Finding (Data Sources)**
Topic 1. MOOC issues' awareness	The guide promoted teachers' awareness of the context issues that affect GLA and made them reflect on the aspects that can have impact on group formation. ([*Quest1*], [*Quest2*], [*Feed_Int*] The guide made teachers change their point of view with respect to their usual collaborative designs to adapt them to MOOC contexts. ([Quest2]) Enrolment closing, requisites to obtain the certificate, and students' geographic dispersion were aspects to consider from the set out of conception of a MOOC with CL. ([Quest2]) Teachers became aware of the impact of several items presented in the guide after the course ending. ([Gen_Obs])
Topic 2. GLA configuration	The moment in the course timeline when the GLA is scheduled was relevant, because the patterns of students' engagement affect its performance. These patterns tend to stabilize about the middle of the course. ([LD], [Feed_Int]) The complexity, time required to accomplish it, and way of describing the activity must be carefully measured in order not to excessively overload students with the GLA. ([LD], [Feed_Int], [Gen_Obs], [Com], [Satis_Sur])
Topic 3. Groups' configuration	The factors related with the course activity (Dynamic Factors) were relevant to configure the groups. ([Quest_T1]) Homogeneity over certain criteria, such as students' timetables, can be useful to obtain suitable groups. ([Quest_T2]) Inactive students in a group strongly affect the satisfaction with the GLA of their teammates. ([Satis_Sur]) To achieve groups with many students' active it is effective to require homogeneity on students' engagement. ([Gen_Obs])
Topic 4. Tool integration	Supporting tools can be integrated into the MOOC platforms through the platform APIs and by processing the files produced by the platform (e.g., .CVS files or internal databases). ([Intg_Obs])
Topic 5. Tool requirements.	The accomplishment of requirements and criteria strongly depend on the students' dataset. ([Crit_Obs])

Table 2: Summary of findings of the study organized by topic

6 Conclusions and Future Work

The study reported in this paper has explored a way in which teachers can be supported in the design and implementation of group formation policies in MOOCs. The information obtained with the study has served to extract conclusions and recommendations that could facilitate the orchestration of collaborative groups and therefore, the implementation of GLA in MOOC context.

The *guide* helped teachers to be aware of the MOOC context issues, to design the GLA and to configure the groups. However, we have extracted some lessons learnt from this MOOC in order to design more successful GLA (i.e., with higher participation, better understanding and accomplishment of the task requirements, and greater student's satisfaction) in MOOC contexts. These lessons learnt should be included in new versions of the guide in order to offer recommendations to the teachers, following our overall DBR process.

We also learnt about the criteria that allow forming suitable groups in MOOC context, finding that it is desirable to achieve groups that avoid inactive members. An heterogeneous distribution of students regarding their engagement level leads to many groups with several inactive students, and therefore it seems preferable to require homogeneity regarding students' engagement.

The *tool* met the specifications, created the groups applying the criteria selected by the teachers, and also served to monitor the activity of the groups. It was successfully integrated with the MOOC platform (i.e., Canvas Network) through a REST API. However, the prototype should continue evolving and enriching with new capabilities, such as an interface that include recommendations, that could be based on an analysis of the available students' dataset, when the teacher selects the grouping criteria. It can also include alerts to inform teachers about the groups' performance as a part of the monitoring capability. The alerts and report information about the groups' activity could be sent daily to teachers so that they can react and intervene if necessary.

In the short term, we plan to carry out another iteration of the DBR process with a new version of the guide and new tool functionalities to keep on exploring and evaluating the framework in new MOOC interventions. The main findings of this study will be checked and analyzed in these future interventions.

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