published as: Thomas Staubitz, Christoph Meinel: Collaborative Learning in MOOCs - Approaches and Experiments, In Proceedings of 48th Annual Frontiers in Education Conference (FiE2018), 3-6 October, 2018, San Jose, CA

Collaborative Learning in MOOCs - Approaches and Experiments

1st Thomas Staubitz
Hasso Plattner Institute
University of Potsdam
Potsdam, Germany
thomas.staubitz@hpi.de

2nd Christoph Meinel
Hasso Plattner Institute
University of Potsdam
Potsdam, Germany
christoph.meinel@hpi.de

***Abstract*—This Research-to-Practice paper examines the practical application of various forms of collaborative learning in MOOCs. Since 2012, about 60 MOOCs in the wider context of Information Technology and Computer Science have been conducted on our self-developed MOOC platform. The platform is also used by several customers, who either run their own platform instances or use our white label platform. We, as well as some of our partners, have experimented with different approaches in collaborative learning in these courses. Based on the results of early experiments, surveys amongst our participants, and requests by our business partners we have integrated several options to offer forms of collaborative learning to the system. The results of our experiments are directly fed back to the platform development, allowing to fine tune existing and to add new tools where necessary. In the paper at hand, we discuss the benefits and disadvantages of decisions in the design of a MOOC with regard to the various forms of collaborative learning. While the focus of the paper at hand is on forms of large group collaboration, two types of small group collaboration on our platforms are briefly introduced.**

***Index Terms*—MOOC; Collaborative learning; Peer assessment; Team based assignment; Teamwork**

I. Introduction

We are offering MOOCs since 2012. In the first year, we used a customized open source learning management system (LMS) to deliver our courses. In 2013 we have started to develop a completely new MOOC management system (MMS) from scratch, as the LMS did not properly scale with the large number of our participants. On our instance of the system (openHPI[1]), we focus on courses in the wider area of Information Technology and Computer Science: Internet security, Web technologies, In-memory databases, programming, but also IT law, entrepreneurship, etc. Since recently, we also offer courses on Design Thinking[2]. We run and maintain additional instances of the system for SAP, a multinational enterprise (openSAP[3]), and the World Health Organization (OpenWHO[4]). Furthermore, we operate a white-label solution that enables also small and medium enterprises (SMEs) and smaller organizations to offer MOOCs (mooc.house[5]). On our partner platforms the range of course topics is wider. openSAP offers more than 100 courses to train customers and partners on the company's products, courses in the area of corporate social responsibilities (CSR), and courses to help their employees (as well as everybody else) to develop more general skills, such as e.g. Design Thinking, sketching, or copy-writing. OpenWHO offers courses to train first responders how to deal with new epidemics outbreaks. While in many of the courses, a general, course wide discussion forum is sufficient to cover the collaboration needs of instructors and course participants, others require more dedicated levels of collaboration, such as e.g. graded teamwork assignments. In the paper at hand we will focus on activities and interventions to foster the participants' collaboration in the course wide discussion forum, mainly to encourage social constructivist discussions. The main question to be answered is, which interventions of the instructors have successfully increased active and passive forum participation.

In Section II we will define the terminology that will be used throughout the rest of the paper. Section III will put our work in the context of previous research. In Section IV we give a brief overview of the data we have examined. In Section V we will discuss the ways, in which we put collaborative learning into practice on our platforms. Finally, Sections **??** and VI will present our future plans and conclude our findings.

II. Definition of Terminology

Collaborative learning, *project based learning*, *teamwork*, and *team based learning* are terms that are often used without a clear distinction. All of these terms describe a method of learning that is based on the idea of working with others to solve a common problem. We distinguish these terms by the following criteria: *Collaborative learning* describes the general process of learning by communicating and interacting with others [3]. This process does not necessarily involve teamwork or team based assignments. Enabling the learners to communicate about a given topic or a task that each of them has to solve and submit individually already fulfills this definition. We differentiate between forms of *Large Group*

[1]https://open.hpi.de

[2]Design Thinking is a user-centered approach for problem-solving and idea development. Stanford University initially developed Design Thinking education programs. The approach has been adopted and implemented by many organizations all over the globe [1], [2].

[3]https://open.sap.com

[4]https://openwho.org

[5]https://mooc.house

Collaboration (LGC) and *Small Group Collaboration* (SGC). We define all forms of collaboration in which participants are interacting with—potentially—all other participants of the course in question as LGC. When subgroups of participants are formed, whose members are supposed to interact mainly with other members of this subgroup, we are talking about SGC. In SGC, we additionally differentiate between loosely coupled groups and tightly coupled groups. We prefer to use the terms *group* for loosely coupled groups and *team* for tightly coupled groups. In loosely coupled SGC, groups are interacting on a certain topic out of their own motivation and interest. We speak about tightly coupled SGC, when teams are working on a common task, particularly, when graded assignments are involved.

III. Related Work

The benefits and challenges of collaborative learning, project based learning, and team based learning are investigated since many years. Springer et al. [4] show positive effects on achievement, persistence, and attitude. Kreijns et al. list deep learning, long term retention, improved social and communication skills, and the formation of social relationships [5]. Laal et al. list the improvement of soft skills, building social support systems, reducing potential anxiety, active involvement in the learning process, better class room results, and increased critical thinking skills [6]. Hiltz et al. state that the results achieved in online collaborative learning can be as good or even better as in a traditional class room setting [7]. The results of those online learners who studied alone (serving as a control group) turned out to be the poorest of all [7]. Vygotsky [8] describes learning as a collaborative activity in which the environment influences the individual. According to his "Zone of proximal development" [8], learners perform better if they receive guidance by more experienced people, which might be either instructors or peers. In this context Mitra [9] showed that these guides do not necessarily need to have more knowledge of the task's topic to have a substantial impact on the learning process of the guided.

Social constructivism, a learning theory building on Vygotsky, defines learning as the process of appropriation of knowledge, not only internalizing it but transforming it in an individual way. Learning occurs through interaction and collaboration, thus, it is an inherently social activity [10].

A. Large Group Collaboration

The participants of a MOOC, particularly those, who—actively or passively—participate in the discussion forum, form a *community of practice*. Wenger [11] has defined a community of practice as based on two pillars:

- Sharing a concern, challenge, or topic,
- Deepening the knowledge on that topic by ongoing interaction.

According to Wenger, communities of practice basically are everywhere and more or less emerge on their own [12]. Grünewald et al. [13], have described how this concept maps to MOOCs. Although we can confirm Wenger's statement that a communities of practice basically have emerged on their own within each of the courses, we also can see that the participation in this community can be improved by some rather simple interventions of the instructors. Section V-A will present our approaches.

B. Small Group Collaboration

Loosely coupled SGC as we defined it in the previous section, basically differs from LGC in the group size. Therefore, we focused on the more tightly coupled forms of collaboration here. NovoEd is one of the few major MOOC platforms that supports the concepts of teamwork and collaboration with powerful tools. Already back in 2013, they offered a MOOC with explicit team based assignments in Spanish language [14]. EdX ran Berkeley's *Engineering Software as a Service* MOOC in 2014. The participants were asked to pair up via Google Hangouts, to conduct pair programming sessions [15]. Rosé et al. [16], report about a "dual layer" MOOC that enabled the students to follow the course in a standard "guided" way on the edX platform or in a more self-directed way in an environment called ProSolo. In the beginning of 2016, several California community colleges announced to bring teamwork to their online classes. Bazaar[6], a tool to support discussions in teams by introducing an AI agent, which triggers and guides conversations among students was to be employed for this purpose [17].

IV. Data Set

Our data set for the paper at hand is the discussion forum data of 45 courses on the (openHPI) and (mooc.house) platforms.

For this data set we defined four coefficients to be compared.

- C1: The average number of forum posts per course participant. This value is defined as

$$C1 = \frac{forumposts - instructorposts}{courseparticipants/courseweeks}$$

- C2: The average number of forum posts per forum contributor[7].

$$C2 = \frac{forumposts - instructorposts}{forumcontributor/courseweeks}$$

- C3: The teaching team's forum activity. The number of all forum contributions posted by course instructors (and other stakeholders such as community managers and subject experts) in relation to the total number of forum posts.

$$C3 = \frac{instructorposts}{forumposts}$$

[6]http://www.cs.cmu.edu/~cprose/Bazaar.html

[7]Determining the exact number of participants, who have actively contributed to the discussion forum by either posting a question, answer, or comment is a rather complex procedure. We have, therefore decided to determine the number of users who posted a question, posted an answer, posted a comment to a question or a comment to an answer seperately and work with the max. of these 4 values as a sufficiently exact approximation.

- C4: The number of participants who are actively contributing to the forum.

$$C4 = \frac{forumcontributors}{courseparticipants}$$

For better comparability, C1 - C4 have been normalized to fit in the range between 0 and 100[8].

The data set itself can be categorized by different criteria.

1) Course Topic: Basically, we have two different categories here.

1) 40 of the examined courses deal with technical IT topics:
   - Five iterations of the course In-Memory Database Management (imdb*)
   - Three iterations of the course Internetworking with TCP/IP (internetworking*)
   - Three iterations of the courser Web Technologies (webtech*)
   - Three iterations of the course Internet Security for Beginners (intsec*)
   - Four iterations of the course Semantic Web/Knowledge Engineering (semanticweb*)
   - Two iterations of the course Python for Kids[9] (pythonjunior*)
   - Two iterations of the course Object-Oriented Programming in Java for Beginners (javaeinstieg*)
   - Two iterations of a workshop complementing the Java course with an introduction to the Eclipse IDE[10] and workshop on Test-driven Development in Java (javawork*)
   - Two iterations of the course Embedded Smart Home (smarthome*)
   - Two iterations of the course Business Process Modeling (bpm*)
   - Courses on data management with SQL (sql2013), parallel programming (parprog2014), e-mail security (ws-email2015), visual software analytics (softwareanalytics2015), how to create your own homepage (homepage2016), Etoys[11] (etoys2016), computer science and genetics (ehealth2016), big data (bigdata2017), search engines (searchengine2017), mainframe computers (mainframes2017), and Linux (linux2018)
2) Five of the courses dealt with non-technical topics
   - Social media privacy (ws-privacy2016),
   - entrepreneurship (startup2016),
   - IT law (it-recht2016),
   - Intrapreneurship (bizmooc2018), and
   - Inspirations for design (insights-2017).

[8]Each value of the column has been divided by the maximal value of the column and multiplied with 100, so, basically this is equivalent to the percentage.

[9]The original German titles of some of the courses have been translated in a way that best describes content and target group of the course.

[10]Eclipse is one of the most common Integrated Development environments for Java programming.

[11]A programming environment for kids

TABLE I
COMPARISON OF COEFFICIENTS BY PLATFORM VERSION

Platform	Avg.(C1)	Avg.(C2)	Avg.(C3)	Avg.(C4)
Version 1	42.0	55.2	35.1	26.5
Version 2	30.8	39.6	36.9	28.6

TABLE II
COMPARISON OF COEFFICIENTS BY ENABLED GAMIFICATION FEATURE

Gamification	Avg.(C1)	Avg.(C2)	Avg.(C3)	Avg.(C4)
Off	30.9	39.0	38.7	25.6
On	30.7	41.1	33.2	35.1

2) Platform version: The courses imdb2012 and imdb2013, internetworking2012, semanticweb2013, sql2013, bpm2013, webtech2013, and parprog2014 have been conducted on the old, LMS-based, version of the platform (V1). All others have been conducted on the new version (V2). To determine if the employed version of the discussion forum had an influence on any of the examined coefficients (C1 - C4), we have compared the average values of these coefficients of the V1 courses with the corresponding values of the V2 courses. Table I shows that the average individual forum activity of the participants in general (C1) and of active forum contributors (C2) have decreased after switching to the new platform. On the other hand, the share of instructor posts (C3) and the number of participants actively contributing to the forum (C4), have slightly increased.

3) Gamification: In January 2017, we released a new feature on our platform (see [18]), with the intent to additionally motivate forum contributions. We compared the average coefficient values of the pre-gamification courses (26) to the post-gamification courses (12) on V2. In this comparison the courses that have been conducted on V1 have been ignored to minimize the number of parameters influencing the result. Table II shows that the average individual forum activity of the participants in general (C1) has not changed at all, while the active forum contributors (C2) seem to be posting a bit more. The share of instructor posts (C3) has slightly decreased, while the number of participants contributing to the forum (C4) has significantly increased. As C3 depends on the total number of forum posts, the decrease more likely is a side-effect of the increased C2 and C4 values than a symptom of less active teaching teams.

4) Course size: We examined if the size of the courses affects the coefficients. The data set ranges from 2635 to 16408 course enrollments. We compared the courses with more than 8000 enrollments to those with less than 8000 enrollments. The threshold has been selected at half of the maximum course size. The results are quite interesting as they confirm that the forum participation in MOOCs works better with a larger number of participants. Table III shows the ratio of active forum contributors to course participants (C4) is the same in the larger courses, the absolute number of contributors therefore, is higher. This seems to positively

TABLE III
COMPARISON OF COEFFICIENTS BY COURSE SIZE

Course size	Avg.(C1)	Avg.(C2)	Avg.(C3)	Avg.(C4)
> 8000	43.2	54.0	31.3	11.9
< 8000	27.1	36.0	31.7	11.3

TABLE IV
COMPARISON OF STATISTIC CORRELATION OF COURSE SIZE AND COEFFICIENTS

	C1-Enroll.	C2-Enroll.	C3-Enroll.	C4-Enroll.
R	0.285	0.400	0.089	0.001
p	0.058	0.006	0.560	0.996

TABLE V
COMPARISON OF COEFFICIENTS BY GRADED HANDS-ON EXERCISES

Graded hands-on	Avg.(C1)	Avg.(C2)	Avg.(C3)	Avg.(C4)
No	26.3	42.1	43.0	20.4
Yes	45.8	42.8	23.9	44.0

influence the individual forum activity of the active forum contributors (C2) and thereby the participants in general (C1). As also the teaching teams' share of the forum activity (C4) stays stable with increasing course size, meaning that, in absolute numbers, the teaching teams are more active in the larger courses. However, running regression statistics on this data also shows that once a certain threshold is reached there is no more direct correlation between these parameters (see Table IV). Obviously, the teaching team (1-10 people) at some point has reached its limits, while the number of participants in the course theoretically is not limited. The interesting question here is, if this affects the participants satisfaction with the teaching team support. We do not have any direct measurement for this. We can only use the participants overall satisfaction with the courses as an indicator. In the majority of the courses we have asked the participants if they would want a sequel of the course and if they would recommend the course to others. Both values are minimally higher in the larger courses.

5) Interactivity: Another parameter that we found worth examining, is the interactivity of a course. To start with, we examined if there are differences concerning C1 - C4 if we categorize the courses by the existence of graded hands-on exercises (see Table V).

The average posts per course participants (C1) are significantly higher, the number of participants contributing to the forum (C4) has more than doubled. Adding graded hands-on exercises obviously draws more course participants into the forums. The instructors' share of posts is comparatively low, indicating that these discussions are social constructivist interactions between participants.

V. EXPERIMENTS AND INTERVENTIONS

Within our MOOCs we have employed basically all of the previously described collaboration forms. Starting with just providing a discussion forum that allows a community of practice to emerge within a course, to experimenting with loosely coupled small groups, and finally peer graded team assignments. Throughout this section we will discuss our experiments and the results that we can see so far. Again, we distinguish between large and small groups.

A. Large Group Collaboration

As described in Section III communities of practice emerge more or less on their own in a MOOC when the platform provides the proper technical support. Our tool of choice for that purpose is the course wide discussion forum. One of the major feature improvements when we switched from V1 to V2 was the newly developed discussion forum. E.g., it enabled the participants to vote for questions and answers and to mark questions as answered. Later on, we added gamification elements that are basically rewarding active high-quality forum contributions (see [18]). We will now discuss three interventions to increase the forum participation.

1) Ice breakers: an introductory post or a little exercise to lure the participants into the forum. The assumption is that once they have posted something, it will be less of a barrier to do it again.
2) Hands-on exercises: we've already shown that adding **graded** hands-on assignments has a very positive effect on the forum participation. We dig deeper now.
3) Triggered discussions: the idea was to start a social constructivist discussion as the tool to convey some of the course contents instead of delivering yet another video.

1) Ice Breakers: In many of our early courses, some user started a "Hello, I'm X. Who are you?" thread. We later adopted this idea and officially initiated such welcome threads. These threads may have not always received many answers. Nevertheless, they directed the participants to the discussion forum right at the course start. We started with this practice in *javaeinstieg2015*. The thread only received 28 replies but with 775 views it was one of the most popular threads in the course. We started similar threads in the courses *javawork2015* (15 replies, 406 views), *ws-privacy2016* (25 replies, 255 views), *startup2016* (28 replies, 282 views), *javaeinstieg2017* (204 replies, 1257 views), *javawork2017* (13 replies, 221 views), *imdb2017* (5 replies, 177 views), *linux2018* (96 replies, 877 views), and *internetsecurity2018* (45 replies, 411 views). These numbers may appear small in comparison to the enrollment numbers, still these threads are amongst the top 3 of most viewed threads in all of these courses. An improved variant of this approach has been introduced in the courses *insights-2017* and *bizmooc2018*, who combined the personal introduction with a small task. In *insights-2017* the participants were asked to bring and introduce 3 personal objects. The first thread basically exploded and received 595 replies and 1086 views. A second thread has been opened, which received another 305 replies and 784 views. In *bizmooc2018* the participants were asked to take a survey that determined whether they're intra- or entrepreneurs and post the results with their introduction. This thread also exploded and received 367 replies and 549 views.

It is important to note that the given tasks in both courses integrated perfectly well with the course topics.

2) Hands-on Assignments: As we have shown in the previous section. Adding graded hands-on exercises has a very positive effect on forum participation. It does not only increase the amount of active forum contribution amongst the course participants, there is also evidence that it improves the quality of the discussions. We have already shown that the forum participation (C4) has almost doubled while the instructors' activity was comparatively low in these courses. We concluded that this indicates a more social constructivist nature of these discussions, being interactions between participants helping each other to solve the tasks. To examine the courses in more detail we have introduced a new coefficient that describes the number and type of hands-on exercises in a course. Generally, our platforms allow to distinguish between main, bonus, and self-test assignments. While *main* assignments count fully towards the certificate, *bonus* assignments can be used to make up for missing points in the main assignments. Self-tests, do not count anywhere. They allow the participants to reflect what they have seen or practically apply the new learned skills without the pressure of being graded. Additionally, some of the courses feature a project, which is a larger task that most often is peer graded. We assigned different weights to the different exercise types.

The projects received a comparably heavy weight:

$$C5 = main * 10 + bonus * 3 + selftest + project * 50$$

The factors that we've assigned to the different exercise types reflect the required workload and their contribution to the course result. As with C1 - C4, we normalized this value to the range of 0 to 100 for better comparability.

Figure 1 shows the direct comparison of the forum participation coefficient (C4) and this newly created hands-on exercises coefficient (C5). The statistical correlation between these values is R=0.542 with a significance of p=0.0001.

Not all of the peaks in the forum participation in Figure 1 can be explained by the existence of hands-on tasks alone. The peak in *bizmooc2018* can easily explained. C5 has a comparably low value as, basically, all hands-on tasks have been self-tests. Additionally, the course featured a project. The hands-on activities themselves, however, were designed as forum discussions and thus directly increasing the activity there as opposed to the indirect activity increase caused by other exercises, such as programming tasks. We will go into more detail on this pattern in the next subsection. The peak in the course *insights-2016* most probably has been caused by the success of the courses' ice breaker exercise and the interactive nature of the course topic. This, basically, leaves us with the smaller peaks in the courses *imdb2012*, *internetworking2012*, *webtech2013*, *webtech2017*, *intsec2014*, and *semanticweb2013*. A closer look at Figure 1, reveals that, except for one, all of the listed courses are the first iteration of a course series. The one exception, *webtech2017*, actually still fits into the pattern as it has been the first major revision of this course.

We have not yet analyzed the contents of the courses' discussion forums in full detail. A preliminary quick walk-through, however, seems to confirm our previous statement that discussions in courses with hands-on exercises tend to be lengthier discussions among the participants on how to solve certain tasks. The focus is on learning how to do something. The lengthier discussions in the other courses are often dealing with assignment issues: mainly the correctness of a given answer and requests for regrading. As we generally do not set deadlines for the hands-on tasks (except for the course end), and the participants can work on these exercises as long as they need, these discussions can be more fruitful by nature as they emerge during the learning process. The focus of discussions related to multiple choice assignments rather leans towards requests for more points or complaints about certain ambiguities in the exam questions. This is quite natural as these discussions trigger a learning process after the grading is done[12]. These findings support the assumption that the peaks in the first iterations of the courses might be caused by ambiguous questions or wrong answers in the course exams. In the following course iterations, these issues probably have been fixed.

Finally, we examined the influence of the instructors' forum activity on the overall forum activity. Figure 2 compares the number of participants' posts to the number of instructors' posts. The values are displayed on a logarithmic scale, as otherwise the differences in the number of instructors' posts would be hardly visible. We have worked with the plain absolute values here, as our coefficients C1-C4 contain too much dependencies for this comparison. The data could be interpreted as evidence for the assumption that active instructors can trigger a higher participant activity. However, we assume that it is rather the other way round. High participant activity in the forum demands higher instructor activity. *intsec2016* is one of the courses where the comparatively high forum activity cannot be explained with the availability of hands-on exercises. A short interview with the top poster of this teaching team—he alone has posted 500+ posts in this course—reveals that there have been a few very active and demanding users in the course that enjoyed to dispute about the course topics. The top three participants in this course alone have posted 635, 269, and 247 times.

3) Self-Test Triggered Discussions: Ambiguous questions are a great trigger for discussions. When they appear in a graded quiz, they often lead to troublesome discussions about points. When they are offered as an ungraded self-test, however, they can be used to explain certain issues more clearly as this would be possible in a video[13]. Basically, there are three different motivations that activate users to discuss such questions in the forum. First, many participants have an intrinsic drive wanting to know exactly why something is one

[12]Removing every possible ambiguity from a multiple choice question, however, often results in trivial questions with obvious answers. We show an approach to deal with this dilemma in the following subsection.

[13]To our experience, this technique is not for the faint of heart, as these discussions can get quite heated.

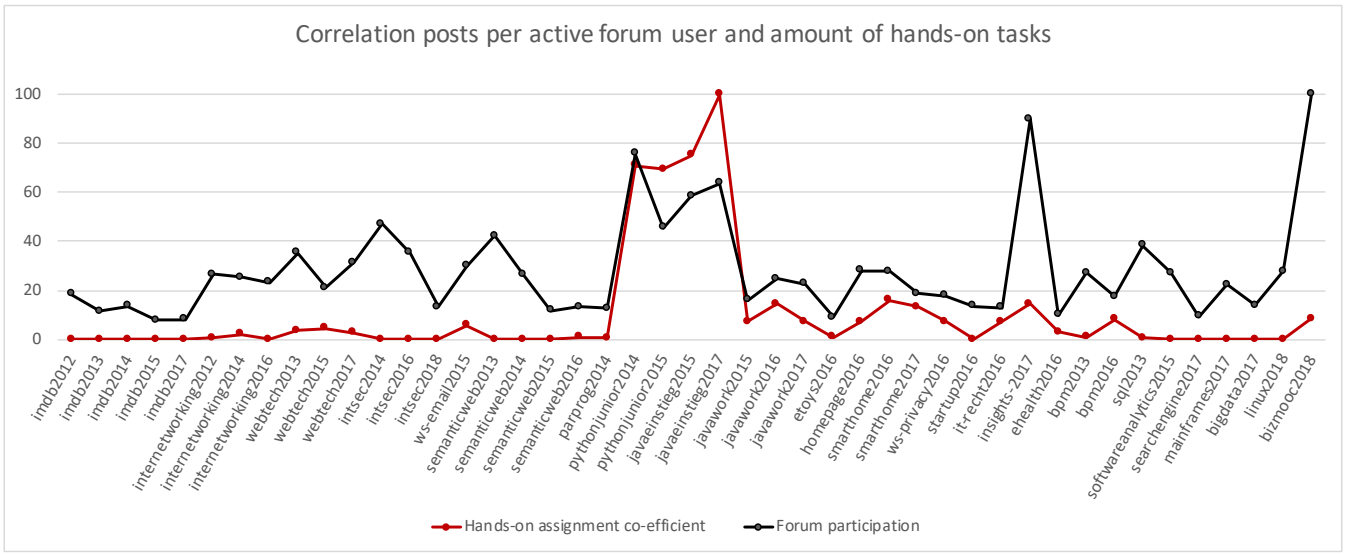

Fig. 1. Correlation of forum participation (C4) and hands-on exercises (C5).

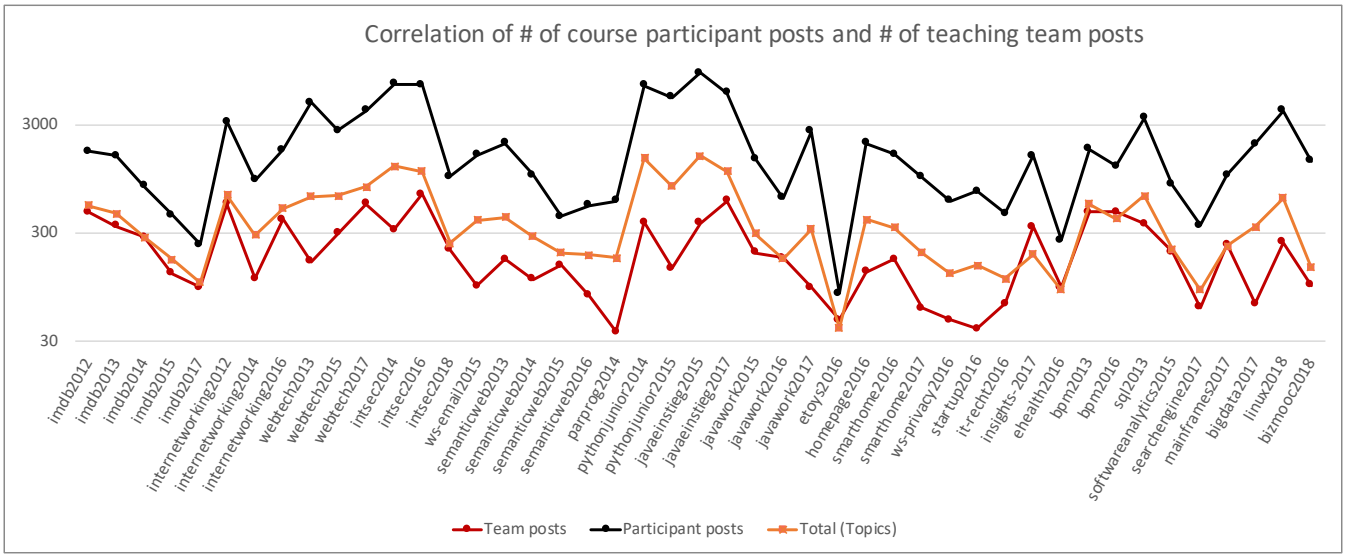

Fig. 2. Influence of number of instructors' forum posts on the number of participants forum posts. This graph shows the absolute number of posts on a logarithmic scale.

way and not the other. Second, the participants expect that a similar question might be offered in a graded exam and want to be prepared. Finally, some participants are motivated by having found a mistake in the "experts" presentation of the topic.

A variant of this method is to make use of funny answers in self-tests[14]. In one of the quizzes of *linux2018* we asked the participants about a Wi-fi cable, and promptly had triggered a quite funny discussion that has received 222 views. A nice side-effect of such questions is that they help to improve the mood in the forum.

Another way to trigger discussions with self-tests is to use them to send participants straight to a thread in the forum and ask them to discuss about a certain topic. The self-test provides three answer options.

- "Yes, I actively participated in the discussion." (1 point)
- "Yes, I read the thread." (1 point)
- "No, I didn't participate." (0 points)

Currently, we do not care if they cheat or not as the self-test

[14]We do not recommend to do that in graded quizzes. From our own experience we also strongly recommend to do a thorough research if the answer that was intended to be funny has not become reality since you learned about the topic yourself.

points do not go anywhere[15]. In *javawork2015* the instructors used this technique to encourage the participants to explore certain topics that are not core elements of the course on their own and discuss their results with others. E.g. the instructors asked who supposedly has said "Do not reinvent the flat tire and why this question is relevant for the course." The thread received 27 replies and quite impressive 1048 views. The extremely high forum participation in *bizmooc2018* is completely based on a variant of this pattern where the students have been asked to upload the result of some exercises and discuss them in the forum. The four threads that have been started for this purpose by the instructors, in total, received 1380 views and 759 replies. So these four threads plus the introductory thread provided about 1000 posts, two thirds of the total forum activity. Another variant of this pattern is to ask the participants to collect and contribute additional course materials. In *sql2013* the instructors used this pattern to collect errata, in some other courses the instructors made the participants collect acronyms and terms to create a glossary. E.g. in *javawork2016* and *linux2018* the instructors started threads to collect additional links and other sources of information. The thread that collected additional links in *linux2018* received 106 replies and 1300 views. In another thread in this course, the instructors asked the participants to provide vendor specific details for a certain procedure that had been introduced in a course video. As these details differ substantially between computer models it would have been impossible to cover all of them in a video. Outsourcing this to the forum turned out to be successful. With 942 views and 53 replies, this thread was amongst the top visited in the course. In *javawork2016*, the instructors asked the course participants how they perceived this approach in the post-course survey. Figure 3 shows the results. About half of the survey participants was not interested in discussing the topic with their peers and either quickly submitted something without following the discussion or skipped the task right away. While only few users stated that they developed a better understanding of the given topic by actively contributing to the discussion, about one third of the users stated they have only been realizing/understanding the subtleties of the topic by passively following the discussions.

Most importantly, encouraging the participants to ask questions and solve them in collaboration with their peers, is the most basic requirement for a course forum to foster social constructivist discussions. In *javawork2015*, *javawork2016*, and *javawork2017*, the participants had to work on a sufficiently complex, yet small project to pass the course. Throughout each of these courses, the teaching team has strongly encouraged the participants to collaborate with their peers whenever they encountered problems. Ask for help with error messages, discuss possible solutions, etc. Anything but copy/pasting complete solutions. The participants made use of this offer in both directions—asking for help and offering help–intensively.

[15]We've already drafted a solution to use this for graded quizzes as well, where the grade will be partially determined by the votes that a post has received.

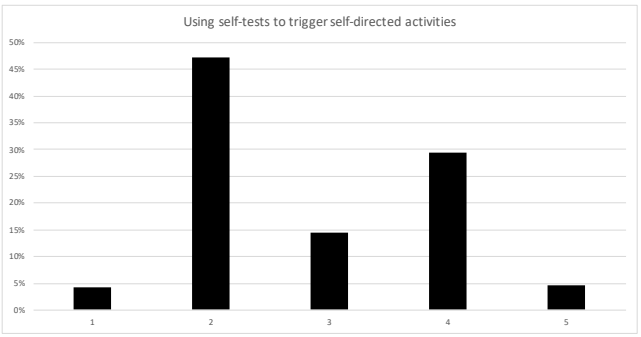

Fig. 3. How do you like the approach to trigger self-directed research activities and discussions in the self-tests? (Question in *javawork2016* post-course survey (n=214).
(1) I skipped this question as I don't learn anything that way.
(2) I tried to answer the question but I didn't follow the discussion.
(3) I read the discussion, but it wasn't very helpful.
(4) Only by following the discussions, I realized the details of the topic.
(5) I actively contributed to the discussion and by that developed a better understanding of the issue.

The teaching team as well offered lots of support. The whole scenario worked more or less how it had been imagined by the instructors. Nevertheless, a few participants, after the course, expressed the concern that they—although they passed—felt as if they've failed, because they wouldn't have been able to solve the problem without all the help in the forum.

B. Small Group Collaboration - Loosely Coupled

We have developed the possibility to create smaller learning subgroups within the overall learning community very early on. The feature on our platforms is called *Collab Space*. The Collab Spaces provide the participants with a private forum, a small set of online collaboration tools and a video chat. For details about the Collab Spaces, see also Staubitz et al. [19] and Staubitz and Meinel [20]. Our original plan was to enable every user to create Collab Spaces and invite friends or peers with similar interests or needs. This plan has been implemented, the feature is available and enabled on the platform since 2014. Use cases that we had in mind, included:

- enabling participants with a mother tongue other than the course language to create a space where they can talk in their mother tongue,
- enabling participants, who are too shy to ask questions in the course wide forum—facing a potential audience of about 10000 peers—to create a more cozy environment with their friends,
- groups of participants of the same school or company,
- special interest groups interesting in digging deeper into a course topic or extending the course by collaboratively exploring topics beyond the actual course scope.

However, the participants do not make use of it to the extent that we have expected. Some examples where it worked quite well are a German speaking Collab Space in the course *intsec2018* which was offered in English, or a group of Debian[16] users in *linux2018*, while the course focused on

[16]A popular Linux distribution

Ubuntu[17]. But these examples are rare. We asked the participants about the Collab Spaces in several post-course surveys. Less than 5% of the participants have used the Collab Spaces. The usefulness of the Collab Spaces was perceived rather indifferently. Most often participants created a Collab Space and then nothing was happening there. Often they even stayed in there alone. In *javawork2016* we created separate Collab Spaces for each of the exercises to bundle the discussions in a more structured way. Our hidden agenda was to lure the participants into the Collab Spaces so that they get more familiar with the feature. The post-course survey (n=212) revealed that the plan has not been very successful. 35% of the participants, despite our promotion efforts, still hadn't noticed the feature at all. Another 28% stated that they never had any problems with the course-wide forum and therefore didn't find splitting the discussions very helpful. Only about 23% found the approach helpful (13%) or at least promising (10%). 14% found the approach harmful. They preferred the course wide discussion forum as this bundled all information in one place and addressed a larger number of participants, leading to faster response times. From a instructor's point of view, we made a similar experience. Based on these survey results and the general lack of interest or proper use of the feature, the consequent step would have been to remove the feature and focus on more successful elements of the platform. In the following section we discuss why we took a different approach.

C. Small Group Collaboration - Tightly Coupled

The major pillar of our definition for tightly coupled small group collaboration is a common graded project that has to be solved collaboratively or cooperatively by a small group of students. In the context of our platforms' team based assignments, it is not differentiated if the teams collaborate or cooperate to solve the task. We use the terms *collaboration* and *cooperation* according to the following definitions by Roschelle and Teasley [21]:

> Collaboration is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem.

and Power [22]:

> Cooperation is accomplished by the division of labor among participants as an activity where each person is responsible for solving a portion of the problem.

To differentiate between loosely coupled and tightly coupled participants, we use the term *groups* for loosely coupled participants, while we use the term *teams* for tightly coupled participants. *Groups* are formed by the participants themselves. They are loose conglomerates of participants that join forces based on a common interest or preference. On our platforms, *Teams* are typically created by the instructors, using a tool that allows a semi-automated matching of participants, based on a set of criteria that can be customized by the instructors based on the course's and the task's requirements (see [20] for more details). To provide a flexible and scalable grading mechanism for these projects, we have expanded the peer grading tool (see [23]) that is integrated in our platforms to allow *team peer assessments*. In a *team peer assessment* one of the team members hands in the team's solution for all other members. Each team member then, individually, has to review and evaluate the work of 3-5 other teams. As the review is mandatory, as a side-effect, it filters inactive team members, preventing them from benefitting of the work of active team members. We have employed team based assignments and team peer assessments, in seven courses on three of our platforms so far. A preliminary evaluation of the data that has been collected during the first six courses, has been encouraging to further pursue this direction. For more details see [24] and [25].

[17]Another popular Linux distribution

VI. Conclusion

We have given an overview on possible forms of collaboration on our MOOC platform and how the collaborative features are employed by course participants and instructors. This research is a first step to better understand if and how the teaching teams' interventions are improving the way the participants interact with each other on the platform's discussion forum. The focus so far has been on the quantitative data. First we have shown that the switch from the old version of our platform to the new one, had rather a negative effect on the average individual forum activity while the share of instructor posts and the number of active forum contributors have slightly increased Next we have shown that the new gamification feature does not have a major impact on the average individual forum activity in general. However, there is a trend that the active forum contributors are posting a bit more. The most important finding here is that the number of participants contributing to the forum has significantly increased. The results in the context of the course size are quite interesting as they confirm that the forum participation in MOOCs actually works better with a larger number of participants. The teaching teams as well are more active in larger courses due to the larger number of questions that need to be answered. Naturally, the teaching teams can only scale to a certain limit. Interestingly, the participants' satisfaction with the courses doesn't suffer from this at all. We have shown that interventions that were well integrated with the rest of the course's content and topic, have very successfully attracted the interest of the participants. While e.g. plain "Welcome" threads already attracted high numbers of participants, an improved variant that combined the "Welcome" thread with a small warm-up exercise has been even more successful. The most successful concept so far, however, was adding hands-on tasks with a certain level of complexity to the course. Ideally but not necessarily, these tasks are graded as this maximizes the number of affected participants. Overall it is very important to create and maintain a relaxing, open, and welcoming atmosphere in the forum to leverage fruitful discussions.

REFERENCES

[1] T. Brown, *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation*. HarperCollins, 2009.

[2] R. L. Martin, *The design of business: Why design thinking is the next competitive advantage*. Harvard Business Press, 2009.

[3] J. M. Gerlach, "Is this collaboration?" *New Directions for Teaching and Learning*, vol. 1994, no. 59, pp. 5–14, 1994.

[4] A. Ellis, A. Brower, A. Burgess, T. Jacob, J. Loftus, C. Middlecamp, B. Mathieu, E. Seymour, and L. Springer, "Collaborative learning, small group learning page," http://archive.wceruw.org/cl1/CL/default.asp, 1997, [Online; accessed 10-01-2018].

[5] K. Kreijns, P. A. Kirschner, and W. Jochems, "Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research," *Computers in Human Behavior*, vol. 19, no. 3, pp. 335 – 353, 2003.

[6] M. Laal and S. M. Ghodsi, "Benefits of collaborative learning," *Procedia - Social and Behavioral Sciences*, vol. 31, no. 0, pp. 486 – 490, 2012, world Conference on Learning, Teaching and Administration - 2011.

[7] S. R. Hiltz, N. Coppola, N. Rotter, M. Toroff, and R. Benbunan-Fich, "Measuring the importance of collaborative learning for the effectiveness of aln: A multi-measure," *Online Education: Learning effectiveness and faculty satisfaction*, vol. 1, pp. 101–119, 2000.

[8] L. S. Vygotsky, *Mind in society: The development of higher psychological processes*, M. Cole, V. John-Steiner, S. Scribner, and S. E., Eds. Harvard University Press Cambridge, Mass., 1978, (Original manuscripts [ca. 1930-1934]).

[9] S. Mitra and E. Crawley, "Effectiveness of self-organised learning by children: Gateshead experiments," *Journal of Education and Human Development*, vol. 3, no. 3, pp. 79–88, September 2014.

[10] A. S. Palincsar, "Social constructivist perspectives on teaching and learning," *Annual Review of Psychology*, vol. 49, no. 1, pp. 345–375, 1998.

[11] E. Wenger, R. McDermott, and W. Snyder, *Cultivating Communities of Practice: A Guide to Managing Knowledge*. Boston, MA, USA: Harvard Business School Press, 2002.

[12] E. Wenger, "Communities of practice: Learning as a social system," https://thesystemsthinker.com/communities-of-practice-learning-as-a-social-system/, 1998, [Online; accessed 21-04-2018].

[13] F. Grünewald, E. Mazandarani, C. Meinel, R. Teusner, M. Totschnig, and C. Willems, "openhpi - a case-study on the emergence of two learning communities," in *2013 IEEE Global Engineering Education Conference (EDUCON)*, March 2013, pp. 1323–1331.

[14] Anne, "Curso evaluación de decisiones estratégicas: Vive el desafío mooc en español," https://novoed.com/blog/2342/curso-evaluacion-de-decisiones-estrategicas-vive-el-desafio-mooc-en-espanol/, 2014, [Online; accessed 10-01-2018].

[15] J. McKinsey, "Remote pair programming in a visual programming language," University of California Berkeley, Berkeley, Tech. Rep. UCB/EECS-2015-139, 5 2015.

[16] C. P. Rosé, O. Ferschke, G. Tomar, D. Yang, I. Howley, V. Aleven, G. Siemens, M. Crosslin, D. Gasevic, and R. Baker, "Challenges and opportunities of dual-layer moocs: Reflections from an edx deployment study," in *Proceedings of the 11th International Conference on Computer Supported Collaborative Learning*, 2015, pp. 848–851.

[17] M. McNeal, "Online classes get a missing piece: Teamwork," https://www.edsurge.com/news/2016-09-28-online-classes-get-a-missing-piece-teamwork, 2016, [Online; accessed 14-10-2016].

[18] T. Staubitz, C. Willems, C. Hagedorn, and C. Meinel, "The gamification of a mooc platform," in *2017 IEEE Global Engineering Education Conference (EDUCON)*, April 2017, pp. 883–892.

[19] T. Staubitz, T. Pfeiffer, J. Renz, C. Willems, and C. Meinel, "Collaborative learning in a mooc environment," in *ICERI2015 Proceedings*, ser. 8th International Conference of Education, Research and Innovation. IATED, 18-20 November, 2015 2015, pp. 8237–8246.

[20] T. Staubitz and C. Meinel, "Collaboration and teamwork on a mooc platform: A toolset," in *Proceedings of the Fourth (2017) ACM Conference on Learning @ Scale*, ser. L@S '17. New York, NY, USA: ACM, 2017, pp. 165–168.

[21] J. Roschelle and S. D. Teasley, *The Construction of Shared Knowledge in Collaborative Problem Solving*. Berlin, Heidelberg: Springer Berlin Heidelberg, 1995, pp. 69–97.

[22] L. Power, "Collaboration vs. cooperation. there is a difference." https://www.huffingtonpost.com/lynn-power/collaboration-vs-cooperat_b_10324418.html, 2017, [Online; accessed 17-01-2018].

[23] T. Staubitz, D. Petrick, M. Bauer, J. Renz, and C. Meinel, "Improving the peer assessment experience on mooc platforms," in *Proceedings of the Third (2016) ACM Conference on Learning @ Scale*, ser. L@S '16. New York, NY, USA: ACM, 2016, pp. 389–398.

[24] T. Staubitz and C. Meinel, "Team based assignments in moocs: Results and observations," in *Proceedings of the Fifth Annual ACM Conference on Learning at Scale*, ser. L@S '18. New York, NY, USA: ACM, 2018, pp. 47:1–47:4. [Online]. Available: http://doi.acm.org/10.1145/3231644.3231705

[25] ——, "Team-based assignments in moocs user feedback," 2018, abstract accepted.