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# Teaching UI Design at Global Scales: A Case Study of the Design of Collaborative Capstone Projects for MOOCs

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## ABSTRACT
Group projects are an essential component of teaching user interface (UI) design. We identified six challenges in transferring traditional group projects into the context of Massive Open Online Courses: managing dropout, avoiding free-riding, appropriate scaffolding, cultural and time zone differences, and establishing common ground. We present a case study of the design of a group project for a UI Design MOOC, in which we implemented technical tools and social structures to cope with the above challenges. Based on survey analysis, interviews, and team chat data from the students over a six-month period, we found that our socio-technical design addressed many of the obstacles that MOOC learners encountered during remote collaboration. We translate our findings into design implications for better group learning experiences at scale.

### ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

### Author Keywords
MOOCs; HCI Education, Collaborative Learning

## INTRODUCTION
The emergence of Massive Open Online Courses (MOOCs) provides an opportunity for higher education to be offered at scale to students across the world. MOOCs remove the limitations of geographical barriers, class sizes, and scheduling, which apply to traditional courses, and allow students to learn anywhere at any time [15]. However, one challenge of transferring the course content to a MOOC format is that MOOC platforms often provide limited support for group projects. Having a team-based capstone project is a proven, effective technique that helps students develop expert knowledge and prepare for their professions [10].

Transferring group projects to a MOOC is not an easy task. Distributed collaboration is notoriously difficult [23]. Furthermore, the unique characteristics of MOOCs make the transfer even more challenging. First, MOOC learners are expected to be much more self-paced, deciding on their desired level of commitment to the course for their goals; this may lead to issues with dropout and/or free-riding [14, 25]. Second, MOOC students lack direct input from instructors regarding their project progress, which creates a need for increased scaffolding. Third, MOOC learners come from diverse backgrounds and thus have varied past experiences, and are geographically distributed, which may lead to challenges with managing cultural differences, reconciling time zones, and establishing common ground [23].

In this paper, we address the following research question: **can we design an online course with sufficient tool support and appropriate social structure to overcome the challenges of remote collaboration in the MOOC environment?**

To answer this question, we built and deployed a technical system *ProjectLens*, together with the necessary social mechanisms to support remote group projects for a user interface (UI) design MOOC. We present a case study of the 88 students who enrolled in the project-based UI design course from June 2017 to December 2017. Our case study shows that it is possible, with sufficient investment in structural and tool support, to create educational group projects that address many of the obstacles MOOC learners encounter during remote collaboration. However, our findings also illustrate potential pitfalls and highlight ways that our tools fell short. We conclude the paper by summarizing the lessons learned and design implications for researchers and for MOOC practitioners.

## RELATED WORK

### Collaborative Learning on MOOCs
Collaborative learning is defined as a group of people learning, sharing knowledge, and solving problems together [9]. Research has shown the benefits of collaborative learning [13]. Team project-based learning incorporates collaborative learning in a problem-solving context, and is a commonly-used teaching and learning method in higher education [30].

Despite the fact that collaborative learning offers many pedagogical benefits, most MOOC classes offer very limited collaborative activities. Margaryan et al [21] assessed 76 randomly selected MOOCs, and found that 68 of the 76 MOOCs had no collaborative activities at all. Zheng et al ([34]) believe that one major reason is that there are limited built-in features to support student collaborations on projects on MOOC Platforms. HCI researchers have conducted studies to design and evaluate innovative tools to support collaborative activities



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among students in large MOOC classes, such as designing peer assessment tools [19] and group discussion environments [18]. However, these studies focus on individual collaborative assignments or discussions, rather than large group-based projects, which involve multiple milestones and deliverables.

One exception is NovoEd, a platform that features group-based projects as the central part of students' learning experience [33]. Students in NovoEd MOOCs can join virtual teams at the beginning of the course, and work with their teammates throughout the duration of the course. Studies have been conducted to identify individual factors that lead to the success or failure of these teams, including leaders' behavior [33] and different team-formation strategies [32]. However, these studies have not considered the group project experience on MOOCs as a holistic process that can be enhanced with careful socio-technical design.

### HCI Education and MOOCs

There is a growing interest in bringing traditional HCI courses online to reach a larger audience. The University of Wisconsin-Madison offers an accredited user experience design course online, where students can complete design projects remotely with other students in the same cohort [1].

HCI courses have also been offered on MOOC platforms, designed with varying levels of collaboration among students. For example, the Interaction Design Specialization program offered by the University of California San Diego [2] and the User Experience Research and Design Specialization program by University of Michigan [3] do not include group-based projects, but instead incorporate collaborative activities such as peer evaluations where students interact with each other. The human-centered design (HCD) course offered through NovoEd [4] encourages students to form teams and complete the class collaboratively. However, relatively little is known about how successful the teams in the HCD class on NovoEd are, or about how to overcome the various challenges of supporting HCI team projects in a MOOC.

### Challenges of Incorporating Group Projects into MOOCs

The unique characteristics of MOOCs create a few challenges for incorporating group projects. First, MOOCs are often characterized as being open and self-paced [5, 6]. Anyone who is interested in the class topic can participate and become a student. MOOC students can negotiate the extent and nature of their participation. In the context of group projects that require the pooling of individual contributions, the "self-paced" nature of a MOOC may lead to dropout (students withdrawing from the group) and/or free-riding (students reducing their efforts without withdrawing from the group) [1, 3]. Dropout and free-riding will have detrimental effects on the motivation of the rest of the group members and on group performance, and can cause conflict [22, 16].

[1]http://hci.wisc.edu/madux/

[2]https://www.coursera.org/specializations/interaction-design

[3]https://www.coursera.org/specializations/michiganux

[4]https://www.plusacumen.org/courses/introduction-human-centered-design

Second, MOOC students lack direct interaction with instructors. When students work on group projects in a traditional classroom setting, they often confer with the instructors to receive guidance on the projects, and receive help on resolving group conflicts. However, it is not possible for instructors to provide so much attention to every MOOC team. One possible solution is scaffolding (providing significant support to students through tools and examples [28]). One concern is that scaffolding might suffocate students' creativity and harm their motivation [20]. Determining the right level of scaffolding becomes a challenge for the instructors.

Third, MOOCs operate on a global scale. Prior literature suggests that when people from all over the world work together in teams, they will encounter distance-related challenges [23]. For example, effective communication requires some level of common ground, which is defined by the knowledge that the participants have in common [8]. However, when people communicate between different locations, they tend to make various assumptions about what their partners know, leading to inefficient communication and collaboration. Another difficulty is time zone differences. The more time zones team members cross, the less capability there is for people to work simultaneously [23]. As distances are spanned, cultural differences can emerge as another big factor. Prior research shows misunderstandings can result from cultural differences [31].

Prior literature suggests that solutions to distance-related challenges have two components [24]. The first part is to select or invent a suite of appropriate technologies that can facilitate long-distance collaboration, which is the "technical way". The second part of the solution is the "social way": by adopting appropriate collaborative practices. Vaish et al. demonstrated the combination of social and technical aspects to build tools that coordinate distributed projects with crowd workers [29].

In this paper, we provide a case study on an ongoing effort to teach a user interface design MOOC with group projects, tackling the aforementioned six challenges — dropout, free-riding, scaffolding, cultural differences, time zones, and common ground using a socio-technical system.

## CASE STUDY: UI DESIGN MOOC

To address the challenges outlined above, we implemented a proof-of-concept system, with each design choice informed by both prior literature and our remote teaching experiences.

### Course Background and Overview

Table 1 provides an overview of the five courses in the User Interface Design Specialization, taught by faculty members from the University of Minnesota and Northwestern University [5]. Each of the first four courses focuses on a major topic in UI design. As group projects are critical to learning UI design, we made the fifth and capstone course a group project. Students work in teams to design solutions to UI design problems. The project includes a balanced mix of activities; some that require a higher level of task dependency (e.g., idea selection, prototyping), and others that are more independent and thus can be divided for members to work on individually (e.g., interviews,

[5]https://www.coursera.org/specializations/user-interface-design

heuristic evaluations). Each project activity requires teamwork and a combination of skills learned from previous courses.

| | Topics |
|---|---|
| 1 | Overview of UI design process<br>Psychology and human factors for UI design |
| 2 | User research methods (e.g. interviews and surveys)<br>Analyzing user data (e.g. qualitative/ analysis)<br>Ideation and idea selection. |
| 3 | UI prototyping techniques<br>Design principles and patterns |
| 4 | Cognitive walkthrough, heuristic evaluation<br>Evaluation with users (usability lab) |
| 5 | Week 1: Project sign-up and group formation<br>Week 2-3: User research and ideation<br>Week 4: Prototyping<br>Week 5: Cognitive walkthrough, heuristic evaluation<br>Week 6: Second prototype and user test plan<br>Week 7: User test<br>Week 8: Peer evaluation |

Table 1: Overview of the User Interface Design Specialization

## Design Workshops

To come up with designs to address these challenges, we conducted three participatory design workshops with participants that had a range of UI design expertise. We invited the instruction team from a graduate-level UI design course (2 instructors and 1 graduate teaching assistant), 2 students from the same UI design course, and 3 researchers with expertise in remote collaboration and human-computer interaction. The instructors had collective UI design teaching experience of 25 years, both in an in-person classrooms setting and remotely through the university's distributed learning service.

We encouraged workshop participants to discuss the obstacles they experienced with remote collaboration. Participants then brainstormed solutions to these obstacles, and ways these solutions could be implemented in a MOOC. Participants' ideas showed two major approaches to addressing their identified challenges: 1) designing solutions with technical systems, and 2) designing solutions with social mechanisms. The research team developed a prototype system based on the workshop discussions and presented it to the same group of participants in the second and third workshops for additional feedback. The participants' feedback is incorporated into the final designs of the prototype presented in this paper.

## Designs of Socio-technical Strategies

We designed a socio-technical system to address the six identified challenges: dropout, freeriding, scaffolding, diversity, time zone differences and lack of common ground. Our socio-technical design has three components: (1) we built a new technical system called ProjectLens (see Figure 1) that manages the group project process, including the matching (and re-matching) of teams, the tracking of team progress, the evaluation of team performance, and management of multiple cohorts of student groups; (2) we provided communication and collaboration technologies to students with instructions regarding how best to use them for the project; and (3) we set up policies and rules and provided instructional materials to guide the MOOC student teams.

In the next sections, we will discuss how the technical and social components collectively address the identified challenges.

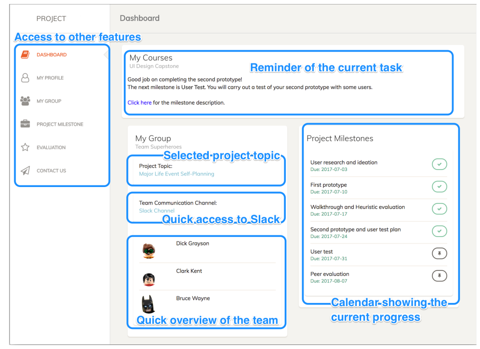



Figure 1: The homepage of ProjectLens, which can be directly integrated with major MOOC platforms

### *How to prevent and cope with dropout*

*Soft Landing:* Student dropout is a common problem for MOOCs [14]. Therefore, we designed two exit points to provide alternative options for students who were considering dropping out. If students found themselves to be a poor match for their current team, they could use the exit points to rejoin another team. This provides a "soft-landing" that allows early dropouts to restart without penalties. The first exit point is when teams have just completed the first milestone of the project. Students choosing to exit at this point would be assigned to another team in the same cohort, and continue working with that team for the rest of the project. The second exit point is set at the second half of the project. Students leaving at this point would be assigned to a new team in the next course cohort.

– Technical component: ProjectLens handles the soft landing automatically. When students choose to leave the projects, they can use the exit points. ProjectLens randomly assigns them to a new team within the same cohort or with the next one, and informs the other students of the changes.

– Social component: We documented the soft-landing policy in written form and made it a required material for students to read prior to starting the project.

*Communication Tools and Guidelines:* Inadequate communication can cause team conflict and lead to dropout. We provide students with communication guidelines — a written document detailing the responsibilities of each team member, as well as advice from the instructors on team collaboration (such as providing constant feedback to team members). We also provide students with the necessary communication platforms and relevant instructions on how to use them. Each student is required to complete training on how to use the ProjectLens and Slack tools before the commencement of the project. We provide each team with private channels on Slack for team discussion, and public channels where students can share knowledge and seek support.

– Technical component: ProjectLens automatically creates Slack channels for teams when the project starts. Each team has a dedicated Slack channel for team communication. The system also reminds teams of the weekly target deliverables.

– Social component: We provide communication guidelines and tutorials on how to use the communication tools.

*Team Size:* We also chose a team size that is suitable for the project. As team size increases, interpersonal coordination becomes more difficult and is harder to coordinate [17]. Having a small team reduces the communication overhead, makes collaboration easier, and reduces the tendency of free-riding. Thus, we set the minimum group size at three, which is the expected number of students required to complete the tasks. Furthermore, to ensure that teams can still function in the case of potential dropout, we start the teams with a size of four or five, which creates a buffer in case dropout should happens.

– Technical component: Course instructors can decide the team size. During the team sign-up, ProjectLens automatically forms teams with the predetermined team size.

### *How to prevent and cope with free-riding*

*Intra-group Peer Evaluation:* Previous studies show that evaluations of individual contributions in group work motivate each member to contribute evenly. When the number of peer evaluations in a course increases, the incidence of free-riding tends to go down [2]. Having peer evaluation gives teams an awareness that even contribution is expected from each member, and thus discourages free-riding.

We require students to complete peer evaluation of their teams weekly. ProjectLens prompts students to complete evaluations of their teammates. Moreover, we require teams to document which part of a project each team member contributed to. Students are expected to rate the overall contribution of each member in the system using a 5-point Likert scale, ranging from "not showing up" to "actively contributing to the project".

– Technical component: ProjectLens automates the peer evaluation process. Students receive reminders and complete evaluations weekly.

*Grading Scheme:* The projects are peer-graded, which allows the course to be automated. Upon completing all milestones in the project, the system conducts a randomized double-blinded peer grading. Each team's project is graded by up to three other teams in the same cohort. Students grade the projects using the rubric provided by the course instructor. After the submissions are graded, the system assigns scores to students based on how much they contributed to the submission. The individual grade received by each student is proportional to the contributions that he or she made towards the project, as informed by the peer evaluation.

– Technical component: ProjectLens arranges the peer grading between teams, and calculates the course grade of each student based on their team contribution.

– Social component: Grading schemes are transparent to teams.

### *What is the ideal level of scaffolding to provide*

*Project Topics:* Instead of asking students to come up with their own project ideas from scratch, we provided teams with a list of project topics to choose from, drawn from well-defined UI problems. Each team discussed and voted for a desired topic at the start. This process can help with the initial ice-breaking, and helps teams get off to a quick start.

– Technical component: ProjectLens enables students to discuss and rank their preferences for project topics. The highest ranked topic is selected for the team.

– Social component: Students are encouraged to brainstorm specific project ideas under the defined project topic.

*Project Examples:* We used the best class projects from the offline course as example projects for the MOOC. Teams from the MOOC can use these examples to guide their own design, or as an inspiration.

– Technical component: ProjectLens provides relevant examples, and informs teams of target deliverables each week.

– Social component: Students are encouraged to discuss the example projects with their teammates.

### *How to cope with cultural and time zone differences*

The geographical location of team members affects both their culture and time zone. Prior literature suggests that these two factors can impact the remote collaboration experience both positively and negatively. For example, cultural diversity can positively influence group decision-making, but negatively affect communication [27]. Similarly, time zone difference could be a challenge for communication but also an asset that allows projects to keep progressing. Given that prior research has not reached a consensus on what the optimal levels of cultural and time zone differences are, we implemented several design variations.

*Team Formation:* To understand how diversity in culture and time zone might affect team performance, we designed our team formation algorithm to ensure that we could perform stratified sampling across two dimensions: (1) teams with members either all located in the same time zone, or all in different time zones, and (2) teams with members all from the same country, or from different countries.

– Technical component: ProjectLens collects demographic information from students during project sign-up, and forms teams with different degrees of time zone differences and cultural differences.

### *How to establish common ground*

*Course Prerequisites:* This is based on the policy set by Coursera. To ensure that students have shared knowledge and vocabulary for the project, students must first complete the previous four courses that cover the basic knowledge and skills required to design successful UIs. We explain to students that this prepares each team with the same level of understanding about UI concepts, which is necessary for successful collaboration.

– Social component: Students are required to complete the introductory UI design MOOCs before joining the Capstone Project. This establishes a foundation for the communication of each team.

## EVALUATION

### Method Overview

Our evaluation is based on analysis from the following sources.

- **Course Performance Data**: We collected data on the students' performance in the course, including their course enrollment, completion, and course deliverables.

- **Interviews:** To understand the students' experience with the group projects, we invited all 66 students who had completed the course at the time of writing to participate in a semi-structured interview. We reached out to students through email and also made the announcement on Slack. We interviewed 9 students (4 males, 5 females) who responded voluntarily, and each interview lasted for 45 minutes. Three interviewees collaborated with teammates in the same time zone, while the other six had worked on international teams.

- **Surveys:** We deployed a survey[6] to the 88 students to understand their general satisfaction with the teamwork experience. Students were invited to complete the survey twice during the eight-week course, at week three and week six. We measured students' general satisfaction with the teamwork, and the challenges they faced in the collaboration process. The questionnaires were adapted based on the work of Bietz et. al [4]. We collected 132 responses in total — 74 responses from the first survey, and 58 from the second survey. Students also answered open-ended questions about the challenges they experienced during the project. The qualitative survey responses were coded together with the interview transcripts.

- **Slack Chat Data:** We collected anonymized text data from the Slack channel of each team, with their consent. Each time a student typed a chat message on the Slack team channel, the message was logged in our secured server.

With the rich data collected from these three sources, we first report the evaluation on course completion, team effectiveness, and the quality of the project deliverables. We use the grounded theory method to analyze the interview data and the answers to the open-ended questions on the survey [7]. We open coded the data and used axial coding to generate themes on how participants tackle the six challenges. The first two authors discussed the themes and revisited the codes to ensure reliability. We present each theme with participants' quotes from participants.

### Course Overview

As of January 2019, 1,604 students had completed the first introductory course of the series, 688 students had completed the second, 642 had completed the third, and 423 have completed the fourth course. These students form the pool of potential learners to join the final course in the series — the capstone project. The capstone project was first launched in June 2017, with a new session starting every four weeks. 88 students signed up and joined in the first six cohorts.

These 88 students (41 male, 47 female) came from 36 different countries and and spoke 25 different languages. 35 students were from North America, 33 from Europe, 16 from Asia, 2 from South America, and 2 from Africa.

#### *Course Completion*

At the time of writing, 66 out of 88 students from 21 teams had finished every milestone and completed the course, with a completion rate of 75%. On the MOOC platform, the capstone course is rated 4.6/5 by 29 students who have completed the course.

#### *Team Effectiveness*

58 out of the 88 students completed both surveys during the eight-week course, on which they reported their experiences with teamwork. The survey evaluated multiple aspects, including satisfaction, common ground, collaboration readiness, management, and technology readiness. From the first survey recorded at week 3, the average satisfaction towards other team members is 3.94 (SD = 1.14) on a 5-point Likert scale. In terms of collaboration readiness, the average team motivation to work together is 3.97 (SD = 1.01), and the average trust in team members' reliability is 3.90 (SD = 1.04). For managing time zone differences within the team, the average is 3.66 (SD = 1.13), and the technology readiness is 4.43 (SD = 0.80).

We conducted paired t-tests on participants' two responses and found that a trend of improvement in the team effectiveness as the projects progressed. From the response data, there was a 0.34 increase in the team motivation ($p<0.01$), and a 0.32 increase in the trust in team members' reliability ($p<0.05$). The survey result also shows improvements in the teams' ability to overcome time zone challenges, with a 0.38 improvement in managing time zone differences ($p<0.01$). Overall, team satisfaction increased by 0.28 ($p<0.05$).

#### *Quality of the Project Deliverables*

We also evaluated the quality of submissions from the teams that completed the course. The projects of the MOOC teams were compared with the projects of teams from the offline Spring 2017 UI design course at the University of Minnesota, which had an equivalent project requirement. Two graduate teaching assistants from the offline course were invited to evaluate the projects using the rubrics set by the instructors. The projects from the 21 MOOC teams and 10 offline teams were evaluated. The average score received by the MOOC teams was 93.6 out of 100 (SD=9.30), while the average score received by offline teams was 78 (SD=17.7). An independent t-test on the scores shows that the difference is significant. This suggests that the MOOC teams performed better than the offline teams. We acknowledge that one potential reason could be that the MOOC teams received additional support that guided them in completing the projects compared to the offline teams (e.g. MOOC students have access to project examples). As a result, MOOC teams were less likely to miss

[6] A copy of the survey with complete questions can be viewed at: https://z.umn.edu/uidesignsurvey2019

requirements as compared to the offline teams. However, the current rubrics do not measure other important metrics such as creativity. In other words, it is not clear whether MOOC teams are more or less creative than offline teams.

### Evaluation of Design Choices

In the following section, we report our evaluation of how our design approach has affected the six specific challenges we identified for transitioning UI design group projects to a MOOC. We also summarize our design decisions with the respective results and trade-offs in table 2.

#### *Dropout*

Among the 88 students enrolled in the course (22 teams), we observed 22 student dropouts from 13 teams. 82% of dropouts (18 students) quit at the first exit-point, within the first two weeks of collaboration. For the 13 affected teams, all but one team went on to successfully complete the project. We found that the majority of dropouts happened at the first exit-point, which is early enough to prevent strong detrimental consequences on team performance. Early dropout allows teams to have enough time to react and adjust their collaboration strategy properly. As one interview participant commented: *"I don't think there is any negative effect on us, because it happened early enough, and we will just get the tasks done with one less person." –P4*

The early exit points and soft landing policies made dropout more predictable, which reduced its negative impact. However, some students reported that they experienced a higher degree of uncertainty and a lack of trust in the early stages of the course, especially before the first exit point. As one interviewee said, *"For the first two weeks, I was not sure if all of my teammates are reliable. I was not sure if someone would decide to leave the team."*

We found that effective communication was also essential to building trust among team members, and had a strong impact on reducing dropout. According to our interviews, the communication tools and guidelines were effective in keeping students from dropping out. Five interviewees used both messaging and voice calls to help with their team communication. Regular communication and updates make students aware of the commitment of their team members. One participant told us that when she noticed her teammates were temporarily disengaged, she would use Slack to check in with them.

However, some participants reported that they experienced a high degree of stress caused by constant communication with teams. Compared to co-located teams, remote teams need to put in extra effort to maintain visibility and presence in the team, which may create stress. In addition to stress, we found that students also felt overloaded by the communication. Having to collaborate remotely, students also over-communicate to stay informed of team progress. The high volume of communication creates cognitive overload, a finding which is consistent with prior studies [12].

Overall, we found that communication tools kept team members engaged and helped to prevent dropout from happening. However, having to handle constant flows of information and communication on multiple communication tools caused stress on team members.

#### *Free-riding*

To discourage free-riding in each team, there were multiple peer evaluations throughout the project, and the grade received by each student was scaled based on their contribution to the team assessed by their teammates.

We analyzed the chat data of all teams to identify any potential cases of free-riding. To check if each team member contributed evenly to the team communication, we computed the Gini coefficient for all teams, using the number of messages sent by each team member. The average Gini coefficient for team communication was 0.154 (S.D. = 0.0927)[7]. This means that for a team with each team member sending on average 100 messages a day, the least participating member would send no less than 74 messages.

Throughout the course, students are evaluated regularly by their teammates for their contributions. From interviews, we found that this motivated students to complete the assigned work weekly. In addition, students also felt social pressure from the evaluation, as they did not want to create difficult situations for team members when evaluating their performance. As such, students would try to complete their work on time, and would expect their team members to do so as well. As one participant elaborated: *"It's actually a reminder of myself that my teammates have to rate me. I take it [peer evaluation] not as a punish way, but a good way." –P1*

The current peer evaluation and grading scheme are designed to evaluate the contributions of each team member to the project deliverables. While effective at encouraging fair contribution and keeping students from free-riding, the evaluations may not have taken certain negative team behaviors into consideration. From the survey, one team reported a team member was disruptive to team communication, despite having completed the expected task.

There are other types of important team contributions, such as interaction with teammates, keeping the team cohesive, resolving conflicts, and other civil behavior in the team. A team member can complete all of the assigned tasks, but still be uncooperative in communication or exhibit antisocial behaviors. In addition, students only receive summative feedback upon project completion. Students expressed a belief that receiving more regular feedback could help them improve their performance incrementally.

We also noticed an interaction between dropout and free-riding. Providing exit points in the project allows students to leave and join a future session if they are no longer able to dedicate their time to the current project. In practice, we found that students would utilize the exit points instead of staying on the team and becoming a free-rider. One interviewee said: *"I have been on holidays from last week and haven't been able to work on the project. Considering how much work has already*

[7]Gini coefficient ranges from 0 to 1, a coefficient of 0 represents complete equality (all individuals have the same amount).

| Challenges | Results | Caveats |
|---|---|---|
| Dropout | Soft landing reduces the detrimental impacts of dropouts by making dropouts happen earlier and become more predictable. | Teams experience lower levels of trust prior to the exit point. |
| | Communication tools keep team members engaged in the project and help with building intra-team trust. | Using multiple tools creates extra and constant communication flows. This causes additional stress and can overload the team members. |
| Free-riding | Peer evaluation and grading schemes create social pressure, which deters team members from free-riding. Exit points allow members to leave the team properly and prevent subsequent free-riding. | Evaluations that only focus on project contribution will neglect other contributions such as team interaction, which is also important to collaboration. |
| Scaffolding | Initial project topic choices save teams time in framing the project and help them get started in their discussions. | Too much scaffolding can backfire. Teams can over-rely on the provided examples, limiting their creativity. |
| Diversity | Teams with cultural diversity also have access to more diverse user groups, which helps generate new insights for design tasks. | Wide cultural diversity requires teams to first find a common language that all members are comfortable with. |
| Time zone Differences | Teams develop different collaboration strategies to overcome time zone differences. Synchronous communication ensures the team progresses at the same rate. Asynchronous communication is easier to execute. | There is not a single communication strategy that fits all situations. Synchronous communication can create burdens on personal lives. Asynchronous communication is less effective for tasks that require input from all members. |
| Common Ground | Completing prerequisite courses builds the teams' shared knowledge and ensures that team members are grounded in communication. | |

Table 2: Results of the six-month system deployment for the UI design MOOC

*been completed I don't think it would be fair to my fellow team members for me to start contributing at this late stage." – P8*

When the team is well informed, dropouts are less damaging than free-riders. Free-riding can happen when important tasks are assigned to the free-rider. When the free-riders are under-contributing, their teams might be unaware of tasks which are not being completed. Ultimately, this will cause setbacks to the team's progress.

### *Scaffolding*

We provided models to the MOOC students, including project topic choices and milestone examples, to make up for the lack of interaction between students and instructors in the MOOC setting. To help students deal with the high degree of uncertainty in the initial team formation stage, a set of project topic choices was provided for the teams. All nine interview participants appreciated having a set of initial topic options to choose from, as that saved time in framing the project early on.

Compared to the topic options, which were well-received by most students, the perceptions of the project examples were more mixed. Some students thought the examples provided instructional scaffolding and gave the team models on which to base discussion. However, some students thought the examples limited the teams' creative space. From the survey data, one respondent expressed unease that his team relied too heavily on the examples when completing their assignments.

The appropriate level of scaffolding is an important consideration in MOOC projects, and future research can continue to explore the right balance.

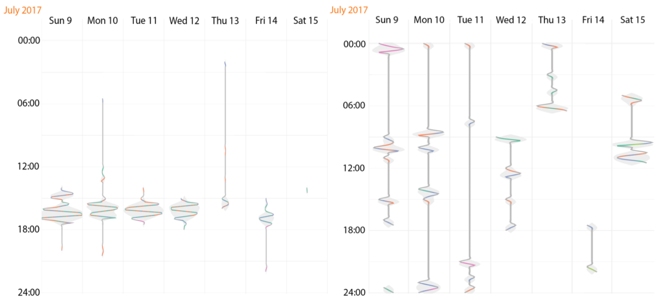
### *Diversity*

Interestingly, our analysis suggests that cultural diversity did not create extra challenges to the collaboration, per the participants who were on the culturally diverse teams. For the course, P5 is from the U.S. and collaborated with team members from Singapore, Greece, the U.S., and Switzerland. While P5 and her team recognized that the team consisted of culturally diverse individuals, it did not affect communication on the team. P5 explained that by treating each other as professional colleagues, the team kept communication on project-related conversations most of the time: *"We didn't notice much cultural differences. In a way, I treated my relationship with my teammates almost like professional colleague who had one of the projects to get done. 95% of the team conversation was professional. We were all so focused on pushing forward each milestone." – P5*

Despite MOOC students coming from different countries with different cultural backgrounds, they share several important demographic characteristics, which might be another important reason why cultural diversity was less of an issue for MOOC students. Prior work shows that most MOOC students fall in the age range of 20–30, and more than 60% hold a professional degree [5]. A major motivation for students to take MOOC classes is to satisfy their professional needs, either for work or for school [35]. These shared demographic characteristics and motivations keep the team discussions effective.

Cultural diversity also implies language differences, but team members were able to find common languages to communicate. Cultural diversity introduces differences in the native languages of team members. Only 40% (N = 35) of the students studied were native English speakers. Nonetheless, all but one team (N = 21) used English as their primary language of communication. The outlying team consisted entirely of students from the same country, and all members on the team used their native language, Russian, exclusively on their Slack channel for the entire project. Among the other teams, team members were able to communicate clearly in English. P9 explained: *"We have one person from Russia, one from South Africa, one from India and I am an American. We are culturally different, but we all speak English. I think in terms of the project it didn't really affected the way we worked together." –P7*

Teams were able to find a common language all members are comfortable with. This result is in alignment with previous findings, which indicate that MOOC students primarily use English to discuss in the forums. We also find that as team communications are mostly about project-related top-




(a) Communication pattern of a synchronous team. The majority of communication happens at the same, fixed time intervals across the week.

(b) Communication pattern of an asynchronous team. The communication happens in short bursts, at irregular time intervals across the week.

Figure 2: Visualization of the communication pattern between synchronous collaboration and asynchronous collaboration style [11]. Each line indicates a conversation thread in the team. The Y-axis denotes the time of the day. The amplitude along X-axis denotes conversation intensity at that time frame.

ics, communication grounding ensures the team has a shared understanding of the discussed topics.

Our result confirms that having diverse backgrounds on a team allows team members to learn from each other, and shows that cultural diversity can help teams generate innovative ideas. Specifically, we found that culturally diverse teams were more likely to find diverse user groups, which is the key to generating interesting and novel ideas for UI design. P7 found this particularly helpful, as it allowed his team to reach out to completely different cultural groups and complete research using a much broader perspective: *"We were able to get a very diverse user group in user research. This gives us a lot more inspiration on our design." –P7*

Overall, language differences did not create a significant barrier to communication, and the diverse cultural backgrounds could be beneficial to generating innovative ideas.

### *Time Zone Differences*

Most students had no previous collaboration experience across time zones. At the start of the project, teams needed to discuss strategies to work together and mitigate the time difference. Time zone differences were cited by our participants as the greatest challenge encountered by their teams. Students found it to be particular challenging to overcome in the early stages of the project. P7 explained that because the team was unfamiliar with working together across multiple time zones, they needed to first discuss how they should collaborate: *"We tried to have a meeting with each other to discuss how to collaborate before the start of the project. Then we realized we work at different time and working individually is better." –P7*

When teams are initially formed, team members have to first come up with collaboration strategies that best fit the team. Overall, we identified two collaboration styles that teams used to deal with the time zone challenges: synchronous and asynchronous communication.

Synchronous communication makes it easier for the team to progress at the same rate, but causes more strain on students' personal lives. Teams that adopted a synchronous collaboration style would set up a fixed time each day for all the members to update and discuss the project. Figure 2a presents one team's Slack messaging pattern in a typical week[8] where almost all the conversations occurred around the same time of day.

Synchronous communication might not work out for every team for two reasons. First, if team members are located across too many different time zones, it can be hard for the team to find a common time. Second, when team members' personal schedules are less flexible, they might not be able to allocate time to join the discussion. When team members need to change their personal schedules too much for communication, or cannot fit the meeting times into their lifestyles, synchronous communication might not be feasible.

An alternative method teams used to resolve time zone differences was asynchronous collaboration. Asynchronous communication is easier to execute, but is less effective for some tasks that require simultaneous input from all team members. Asynchronous communication allowed team members whose schedules could not fit together to still work and communicate. Team members do not immediately receive or respond to requests from their teammates. Figure 2b visualizes one asynchronous team's Slack messages, which show that communication can occur at any time of day. One participant described how his team worked: *"The nice thing about this is we can always keep the progress 24 hours a day, because someone is always working on it. So, we just pass over and someone would work on it." – P1*

Asynchronous communication requires teams to divide up the work into smaller parts, each member working on a part individually before putting the work together. The effectiveness of the approach depends on the nature of the task. If a particular task requires simultaneous input from all team members, asynchronous collaboration might not be the ideal strategy.

Time zone differences introduced a challenge to MOOC students, but teams managed to engage in different strategies to overcome its negative impacts. The survey result also confirmed this – the average ratings on teams' ability to communicate across time zone differences increased from 3.65 to 4.03 from the first half of the course to the second ($p < 0.01$).

### *Establishing Common Ground*

Completing prerequisite courses established common ground for the teams and helped to build shared knowledge for communication. We required students to complete the previous four UI design courses before starting the group project, so that students could share common knowledge about UI design concepts and terminology for their collaboration. Interviewees found this design effective: *"Yes it helped a lot. Otherwise you will have to explain what you mean all the time to your teammates. So, if you all have the same background and are at the same page, you are essentially speaking the same language and it really helped." –P2*

[8]The messaging pattern of the team was consistent across eight weeks; therefore, we picked the week with the highest activities.

To analyze the content of the team discussions, we further looked into the vocabulary usage in communications from all teams. We performed keyword and phrase extraction and ranked the keywords used in team communication based on their semantic importance and occurrences [26]. 7 of the top 20 keywords were ideas and concepts taught in the previous MOOC courses (e.g. *user research, user test, cognitive walk-through*). The remaining keywords include the features and applications that the teams were designing. This indicates that students were communicating in a common professional language, and confirms that our design was effective in helping students establish common ground for their collaboration.

## DISCUSSION AND IMPLICATIONS

In this case study, challenges came from the complex, real-world characteristics of MOOCs, which include distant collaboration and platform-specific constraints. Our study shows that with sufficient investment in tool support and social support, it is possible to teach a team-based UI design course at a large scale. The tools and structural support we provided collectively handled the routine or repetitive tasks in managing teams, and helped to prevent and deal with potential team breakdowns. This allows instructors to focus more on tasks that utilize their knowledge and experiences, such as designing the actual content of the course.

It is worth noting that as a case study, the coping mechanisms discussed are designed for teaching UI design, and may not directly generalize to all other MOOCs.

### Implications for Design

*Develop centralized communication systems*

Our findings suggest that communication tools keep team members engaged in the project. However, multiple communication channels can be overwhelming and cause additional stress. One solution is to develop centralized communication systems that automatically retrieve and synthesize information from multiple sources, such that students do not have to navigate across multiple sources to keep updated.

*Automatically identify potential dropouts early*

Researchers can develop systems to automatically detect early signs of dropout based on team communications or discussions. The system can intervene to bring the faltering team members back to the team, or to help match them with a new team. By identifying dropouts early in the collaboration, less damage is done to team progress.

*Prioritize "latitudinal diversity" and "longitudinal uniformity"*

Our results show that while diversity in cultural backgrounds can bring new ideas to a team, time zone differences add challenges to the collaboration. In general, a good team composition should prioritize (1) having members from similar longitudes — which minimizes time zone differences — and (2) having members from different latitudes — to form teams with different cultural backgrounds. Teams with members from North America and South America, or with members from Europe and Africa, are some good examples. Future team formation should take this into account and maximize team diversity while minimizing time zone differences.

*Warm up tasks to quickly determine the match*

Our findings suggest that exit points provide alternatives for mismatched team members and create soft landings. One possible way to quickly assess the "match" between the members in a team is to set up a "warm-up" task. Following team formation, the team can be first given a simpler, shorter task that requires teamwork, before the actual project commences. The team can develop collaboration strategies for the later project, while also building trust in the process.

*Team size*

It is important to consider the likelihood of member dropout when deciding group size. While a smaller team can reduce communication overhead and is more efficient in remote collaboration, member dropout might introduce more detrimental impacts on small teams. Therefore, instructors can form teams with one or two more than the necessary number based on the task workload. In our case study, 13 teams lost members due to dropout, yet all but one team completed the project thanks to having extra members as buffers.

*Frequency and type of peer evaluation*

In addition to evaluating task contributions, peer evaluation should also give feedback on team member effectiveness, including how cooperative and effective the communication of the team member is. Continual peer feedback allows students to understand where they are performing well, and what they should they focus on to improve. Receiving qualitative feedback also allows students to adjust their collaboration style to fit the team. However, peer evaluation that is too frequent might also be taxing for students.

## CONCLUSION

In this work, we discuss the six identified challenges of transferring a university UI design course into a team project-based MOOC experience: managing dropout, avoiding free-riding, appropriate scaffolding, cultural differences, time zone differences, and establishing common ground. We present designs that address these challenges from both technical and social perspectives. The case study shows how the designs support MOOC learners in completing a collaborative project.

We demonstrate how our socio-technical design helps student cope with the challenges of collaboration. We also discuss potential pitfalls that can come with each of the designs. We relate our findings to implications for the design of compelling collaborative learning experiences at scale.

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