

# ORGANIZING A SHORT ONLINE MATH PROGRAM SUCCESSFULLY

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**This article will appear in the Notices of the AMS in March 2021.**

## 1. INTRODUCTION

Since 2012 the University of North Carolina at Greensboro has held an annual summer school in computational number theory aimed at first and second year graduate students. This year we were in charge of running the school, entitled *An Introduction to Ergodic Theory via Continued Fractions*. Given the ongoing Covid-19 outbreak, we decided, in mid-March, to run the school entirely online.

In this article we will describe how we carefully tried to preserve as many desirable features of an intensive summer school experience as we could online. Since surveys indicated that the participants were uniformly pleased with their experiences, we hope that our account will help others who wish to organize similar online events.

## 2. PLANNING

We decided to organize the summer school around mini-lectures and small group problem solving sessions in order to promote active engagement with the material and each other. Group size was the major factor in determining how many participants to accept: five groups of three students each enabled us to realistically prevent any student from falling behind. We began advertising the summer school and soliciting applications 6 weeks before the start date. In a window of 3 weeks, we received more applications than spots for the program. Before the program began, we wrote detailed lecture notes and problem sets to be distributed to the students each day of the school. *We believe that the lecture notes and the small highly monitored and advised problem solving groups we created were the crucial factors that made our good results possible.*

## 3. TECHNOLOGY

With the majority of the participants' time spent in problem sessions, we wanted to make sure that they would be able to communicate mathematical ideas to each other easily and clearly. We were able to get funding agency approval to re-direct travel funds to purchase webcams for participants who needed them, provided they were returned to UNCG at the end of the school. We also offered hand-held whiteboards and markers to participants as a low-tech way to present mathematics over the internet.

We settled on Zoom as a medium for the summer school. Many people were already familiar with Zoom from their home institutions and it satisfied most of our

requirements. The four lecturers each used their own method to present material during their lectures.

- Writing on a tablet screen that was shared to participants.
- Presenting at a wall-mounted whiteboard via webcam.
- Writing on paper using a webcam as a document camera.
- Screen-sharing a Mathematica notebook to discuss its code.

All the methods were reasonably successful, bolstered by our posting of complete lecture notes and problem sets online daily. Most methods do not allow the lecturer to simultaneously monitor the Zoom meeting, so when points were raised via the Zoom chat it was the responsibility of the other organizers to alert the lecturer if an immediate response was needed.

We used the “breakout rooms” feature of Zoom for the problem sessions, with the host partitioning participants into five breakout rooms at the end of each lecture.

We set up a separate chat in Discord for the organizers to discuss matters such as who would help in which breakout room, what would be discussed after the problem sessions, and hints and solutions to specific exercises. It was very helpful to have a place to chat outside Zoom, both to keep organizer discussions separate from discussions with participants, and because the chatroom persisted beyond the current Zoom meeting.

#### 4. EXPERIENCE

Students enthusiastically engaged with each other during the 90 minute breakout room problem sessions, routinely forgoing the suggested 15 minute break. In an effort to reduce fatigue and avoid settling into a routine, we changed the composition of the small groups each session; held a special lecture on computational aspects of the material; offered a research-level lecture at the end of one day; and held a “social hour” in the middle of the week in which we shared stories, showed off our pets, and played online games.

The online format made monitoring students’ reactions to the lectures and problem sessions more of a challenge than usual. In addition to pausing frequently to allow students to ask questions, we sent an email after the first day asking students about the experience. In response to the feedback, we adjusted how much guidance we gave during the problem sessions. On a few occasions we changed problem session group compositions on the fly to support participants who didn’t feel their current group was a good fit for them. *We felt it important to get feedback on potential problems mid-session while we could still do something to fix them.* After the summer school ended, we sent out a survey to ascertain how the participants felt about the school as a whole. Some of the questions specifically asked for feedback on the online organization of the school.

The responses to the surveys were mostly positive: participants enjoyed the school, were happy with its organization, except for the necessary requirement that they spend many hours in front of a computer. Importantly, they did not feel that their learning was impacted and said they were able to get their questions answered easily in our format.

We sent out a concluding e-mail pointing out additional resources and what further steps could be taken to continue learning about ergodic theory and continued fractions. Our lecture notes also pointed to further results.

## 5. CONCLUSIONS

Our experience indicates that technology makes it possible to run a summer school such as ours online, and that students will participate enthusiastically. While the possibilities we lost – such as working together at the board, informal one-on-one chats, and external social activities – are valuable, we gained by being able to hold the school at all given the current situation, not having to spend very much money to run the workshop, and not needing to travel away from home to be together. With a few tweaks to the technology, and broad access to it, there is no reason why online summer schools shouldn't play a prominent role in promoting and disseminating mathematics. Be it by choice or necessity, we wish you the best in organizing a similar meeting online.

As a service to those who would like to organize a similar event, we have collected a list of helpful technology tips and tricks here: <http://go.uncg.edu/ergodictheory>

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## 6. APPENDIX

This appendix accompanies the article, *Organizing a short online math program successfully*. It explains some of the more practical aspects of organizing a short math program online.

**6.1. Problem sheet design.** Consider making problem sessions the major component of the school, as opposed to lecture presentations. Short lectures can be used to introduce ideas and major results. Problem sets should not be so long and unguided that participants don't know where to start, and must have a reasonable progression of difficulty to accommodate all participants.

Reducing the amount of time participants spend absorbing material through lectures means that a complete set of notes is a necessity, and that the problems sets should both follow naturally from the brief presentations that are given, and be achievable using the notes alone. Designing short lectures and problems will take a significant amount of time, but will - based on participant feedback and our experience - result in a more engaging experience for most.

**6.2. Group management.** Small group problem sessions seem to run most smoothly with groups of 2 or 3 students each. Our program enjoyed a student to instructor ratio of 3:1, so each group had instant access to an instructor whenever requested. Depending on the material, quality of the notes, and difficulty of the problem sets,

one instructor may reasonably be able to handle up to three groups. Holding yourself to this ratio will cut down on the number of students you can admit, but the experience of admitted students will be much better.

Our program had four or five faculty members, besides the organizers, assisting in the breakout rooms and sometimes staying the entire problem solving session if they were welcome. Many of these faculty members were new to the material, so it was natural for them to present themselves as fellow students and not take over the session.

We permuted membership in the groups daily to promote mixing and meeting. This was accomplished in our case by following a solution to Kirkman's schoolgirl problem. The experience of a few meetings may give you enough information to begin forming the groups more deliberately so as to ensure everyone is having a positive experience. Your impressions coupled with a survey to the students mid-course can help you decide on groups., you may decide not to form groups entirely randomly

**6.3. Building community online.** A positive sense of community helps to build an atmosphere conducive to learning math together. This is more difficult to achieve with online-only meetings. Consider scheduling a meeting or two with the purpose of building this community.

- At the beginning of the program, schedule time for everyone to introduce themselves. This may take time with a large group, but the return may be worth the investment. Some traditional ice-breaker games can be translated to the online setting; if you need to break out into groups, the Zoom breakout room feature allows you to do that.

Here's an idea for the very first meeting that can serve as an icebreaker and an informal introduction to the topic at hand. Program organizers create the outline of a slideshow on a cloud platform such as Google Slides. The outline includes one slide with a title per topic. The slide titles will be program content-specific and can be focused on people, historical facets of the topic at hand, key foundational results, etc... Participants are broken into groups and each group has 15 minutes to fill out one slide, adding pictures and facts. When the group reconvenes, each group take their turn doing a mini-presentation to the whole group with the help of their slide. Participants likely won't have time to put a polished presentation together, but that's part of the fun.

- In the middle of the program, it can be a nice break from math to have a social hour meeting. Participants can bring food, drinks, and show-and-tell (eg. pets). Breakout rooms allow participants to gather based on what they want to do: chat, play games, group watch a movie, etc... Here are some online games we found to be amenable to this type of meeting:
  - The Math Is Fun Games Room, <https://www.mathsisfun.com/games/puzzle-games.html> There are a lot of puzzle games on this site. One person can play via screen share and everyone else can shout out their next moves to them.
  - The Pictionary Room <https://www.drawize.com> Choose the "Play with Friends" option to give people a link so that you can all play "Pictionary" together. You get a word and try to get everyone else to

guess the word from the picture you draw. You thought you couldn't draw before? Try it online!

- The Codenames/Codewords Room <http://codewordsgame.com> Choose the "Create Game" option to give people a link so that you can all play "Codenames" together.
- The Dominion Room <https://dominion.games> Dominion is a popular deck-building card game, and this online adaptation is very close to the original.
- A conference photo. For groups that aren't too large, everyone's webcam can fit in the same page of a Zoom meeting. Anyone can then take a screenshot to function as a conference photo.
- At the end of the program, consider scheduling a "send-off" to tie up loose ends and have a more structured "good-bye" than just logging off. Participants can reflect on what they learned, trade contact info, talk about future plans, etc...

**6.4. Technology overview.** In this section, we describe how we used Zoom (<http://zoom.us>) and Discord (<http://discord.com>) to run our online school. What we describe here is possible with "out-of-the-box" versions of the software, with no special set-up or permissions required. The following is current as of July 2020.

Zoom was used for the daily meetings. At least one organizer should have a Zoom license so that meetings can run for longer than 40 minutes. The organizer should schedule the school's meetings ahead of time and disseminate the link to the participants. There are a number of options to consider for the meetings:

- "Require meeting password" requires participants to have the meeting link and a password to join. Meeting links are private and generally security enough, but passwords work well if you want to publish the meeting link but have a way to securely disseminate a password to the intended participants.
- If "Enable waiting room" is checked, those who join the meeting will be met first with a waiting room screen. The host chooses when and whom to allow into the meeting. (Request that participants access the Zoom client using the name they used when registering for the event.)
- "Enable join before host" allows participants to meet without the host. There are some things to consider when deciding on this feature. If participants are encouraged/allowed to work together outside of the meeting times, then they can use the usual Zoom meeting room to coordinate. Depending on your institution, though, there may be some liability implications should anything bad happen in the meeting room outside of usual meeting hours. The "Enable waiting room" and "Enable join before host" features cannot both be enabled at once.
- Meeting link/password dissemination. To avoid unwelcome participants and disruptions such as Zoombombing (<https://en.wikipedia.org/wiki/Zoombombing>), it is a good idea to protect the link to your meeting. A password may help add another layer of security. If you have a small number of participants, a waiting room can also help with this by allowing you to manually allow only the participants you recognize to join the meeting.

It is very convenient for the meeting organizers to have a ‘side chat’ outside of Zoom to use for coordination. Any messaging app can be used for a side chat; we used Discord. Here are a couple of ways we used the side chat.

- Instead of broadcasting a message to all breakout rooms, the host can co-hosts can coordinate a message in the side chat that can then be delivered to each of the breakout rooms individually by speaking or by breakout room chat. This is useful because broadcasted messages in Zoom are easily missed and disappear without a trace.
- Organizers can ask other organizers for insight into or answers to a student’s question before responding to the student.
- During meetings, organizers were able to collectively write a list of topics to summarize at the end of the school meetings. This list was continuously updated / modified based on the organizers perception of students’ understanding of the material.

Having the side chat outside of Zoom also guarantees that there’s no way that organizational messages are accidentally sent to students.

**6.5. Breakout room problem sessions.** The meeting host can split participants and co-hosts into breakout room groups with the “Breakout Rooms” button. There is a limit to the number of rooms (<https://support.zoom.us/hc/en-us/articles/206476313-Managing-breakout-rooms>). The splitting can be done ahead of time and initiated whenever needed. On some versions of Zoom, breakout room lists can be formed even before the meeting is started.

Participants can enter their breakout room and return to the main room at any time. The meeting host can join any breakout room by clicking the breakout rooms button. Co-hosts can also join any breakout room, but the process is not as simple: co-hosts first enter the breakout room to which they were assigned, then they can join any other breakout room by clicking the breakout rooms button. (From the home room, co-hosts can only join the breakout room to which they were assigned.)

Each breakout room has a chat which allows participants to chat only with other members in the same breakout room. Under no circumstance does a breakout room chat leave the current breakout room. Breakout room participants can call the host for help by clicking “Ask the host for help.” It appears that the meeting host is the only person outside of a breakout room that a participant can send a signal to.

Conversely, the host is the only one with the ability to “broadcast” a message to all members of all breakout rooms at once. This can be done by clicking the broadcast button in the breakout rooms window. This is not an ideal way to communicate. The message only appears briefly and is not recorded. It is very likely that participants will miss the message.

It is convenient to have an “instructors-only” breakout room for instructors to gather while not helping students. There are two reasons: 1) co-hosts can move from this room to any other breakout room (unlike moving from the main room to a breakout room); and 2) students cannot join the instructors-only breakout room (without being assigned), preventing the scenario in which instructors are chatting in the main room and a student joins to overhear them. As a word of caution, the host should monitor the main room for new arrivals via the breakout rooms list: if the host is in the instructors-only breakout room, it will not be apparent if a new participant joins the meeting or a students return from their breakout room

(possibly in search of help). The host or a co-host might consider using a second device to stay in the main meeting room.

**6.6. Communicating mathematics over video chat.** Here are some ways to effectively communicate math over video chats:

- Microphone and webcam. A microphone is a necessity, and a webcam is strongly encouraged (if for nothing else than to build community). A smartphone usually has both of these but is best as a peripheral device; the screen is too small to be used as a primary device.
- Document camera. A document camera allows you to easily share what you are writing. A document camera can be easily fashioned out of a smartphone and a smartphone clamp holder.
- Tablet. A tablet computer or a digital writing surface allows for clear writing on a digital whiteboard.
- Whiteboard and markers. Combined with a webcam, math can be hand-written on a whiteboard for presenting to others. It is best to be able to mount the whiteboard and train the webcam on it so as to avoid having to hold it while writing and to avoid the webcam losing focus.

The combination of a microphone and a tablet with stylus / digital drawing surface seems to work best: the participant with the tablet clicks “share screen,” then “whiteboard” in Zoom to share a blank board with the other participants. (The host must change a setting in Zoom to allow any participant to share their screen.) They can write neatly with a stylus on the board. Anyone can write on the whiteboard (by clicking “Annotate” in the dropdown menu at the top of their screen) and whiteboards can be saved by anyone for later use. Drawing with a mouse is an exercise in patience, but those who have styluses can collaborate neatly.

**6.7. Exit Survey.** Here is the exit survey we used to gather feedback about our program.

*We would very much like to hear about your experience at the school. Your responses will help improve future schools and are anonymous.*

- This survey is anonymous. If you are willing for your opinions to be attributed to you please write your name here.
- Rate on a scale of 1-5, with 1 the worst and 5 the best, your overall experience with the summer school.
- Rate on a scale of 1-5, with 1 the worst and 5 the best, the quality of the lecture material.
- Rate on a scale of 1-5, with 1 the worst and 5 the best, the quality of the delivery of the lectures.
- Rate on a scale of 1-5, with 1 the worst and 5 the best, the degree to which the lectures prepared you for the problem sets.
- Rate on a scale of 1-5, with 1 being poor and 5 being excellent, the quality of attention you received from the lecturers during the problem sessions.
- Rate on a scale of 1-5, with 1 the worst and 5 the best, the ease with which you could get your questions addressed.
- Please tell us about your experience with the school overall.

- What comments, if any, do you have about the lectures? (E.g. content, presentation.)
- What comments, if any, do you have about the problem sessions? (E.g. composition, duration.)
- What technical difficulties, if any, did you have during the school? Were they resolved?
- What do you feel worked better or worse because the school was online instead of on the UNCG campus?
- Are there any other comments you would like to make about the summer school?

It is wise to put out at least one survey during the school asking participants for feedback on how things are going. Prompt for feedback on aspects you want to be sure are going well but also leave room for open-ended responses and anonymity. You want to learn about problems while you still have an opportunity to fix them. With this feedback it might become obvious that you should improve your mix or your methods of delivery and activities.